Division of Biological Sciences

The Division of Biological Sciences provides a unified curriculum for undergraduate majors enrolled in either the College of Agriculture and Life Sciences or the College of Arts and Sciences. Courses in biological sciences are integral to many disciplines and are a basic requirement in many schools and colleges at Cornell.

Graduate study in the biological sciences is administered by more than a dozen specialized fields within the Graduate School as described in the *Announcement of the Graduate School*.

Facilities

The Division of Biological Sciences is composed of six major sections: Biochemistry, Molecular and Cell Biology; Genetics and Development; Ecology and Systematics; Neurobiology and Behavior; Physiology; Plant Biology; and two smaller units, the L. H. Bailey Hortorium and the Shoals Marine Laboratory.

The offices, research laboratories, and classrooms of biology faculty members are located in many different buildings both on and off the campus, but most are in the Colleges of Agriculture and Life Sciences, Arts and Sciences, and Veterinary Medicine.

The division's Office for Academic Affairs and the Behrman Biology Center are centrally located in Stimson Hall to provide academic advice, counseling, and information to undergraduates. The Office for Academic Affairs also follows the progress of biology majors and works closely with faculty advisers. Additional services and resources of the Biology Center include academic program planning, tutoring, lecture tapes, examination files, and information on undergraduate research opportunities. The center has comfortable areas for studying and relaxing.

The Shoals Marine Laboratory, a cooperative venture with the University of New Hampshire, is located on a small island in the Gulf of Maine. Its base office in Stimson Hall provides advising and career counseling for students interested in the marine sciences and administers the SEA Semester Program for Cornell students pursuing studies at Woods Hole or aboard the schooner *Westward*.

Faculty

R. Barker, director; H. T. Stinson, associate director; K. K. Adler, M. Alexander, W. J. Arion, J. P. Barlow, D. M. Bates, A. Bensadoun, E. N. Bergman, K. W. Beyenbach, A. W. Blackler, S. E. Bloom, A. C. Borror, E. B. Brothers, W. L. Brown, P. J. Bruns, P. F. Brussard, W. R. Butler, T. J. Cade, J. M. Calvo, J. M. Camhi, R. B. Campenot, R. R. Capranica, B. F. Chabot, J. L. Cisne, R. K. Clayton, R. A. Corradino, W. B. Currie, P. J. Davies, E. A. Delwiche, W. C. Dilger, W. L. Dills, A. Dobson, W. J. Dress, S. J. Edelstein, T. Eisner, S. T. Emlen, H. E. Evans, P. P. Feeny, G. W. Feigenson, J. M. Fessenden-Raden, G. R. Fink, R. H. Foote, J. E. Fortune, T. D. Fox, E. L. Gasteiger, J. Gibson, Q. H. Gibson, J. H. Gillespie, C. A. S. Hall, B. P. Halpern, G. G. Hammes, W. Hansel, R. M. Harris-Warrick, G. Hausfater, L. A. Heppel, G. P. Hess, P. C. Hinkle, K. A. Houpt, T. R. Houpt, H. C. Howland, R. R. Hoy, J. W. Ingram, A. T. Jagendorf, M. N. Kazarinoff, E. B. Keller, K. A. R. Kennedy, J. M. Kingsbury, T. A. LaRue, F. W. Lengemann, A. C. Leopold, S. A. Levin, G. E. Likens, J. T. Lis, E. R. Loew, R. E. MacDonald, R. J. MacIntyre, J. T. Madison, P. L. Marks, R. E. McCarty, W. N. McFarland, J. K. Moffat, K. J. Niklas, J. D. Novak, D. J. Paolillo, P. J. Parker, M. V. Parthasarathy, D. Pimentel, T. R. Podleski, F. H. Pough, W. B. Provine, E. Racker, E. Adkins Regan, G-Y. Rhee, M. E. Richmond, S. J. Risch, J. W. Roberts, R. B. Root, M. M. Salpeter, P. W. Sherman, R. M. Spanswick, A. M. Srb, A. A. Szalay, D. N. Tapper, J. F. Thompson, B.-K. Tye, C. H. Uhl, N. W. Uhl, P. J. VanDemark, A. van Tienhoven, V. M. Vogt, R. H. Wasserman, M. D. Whalen, D. B. Wilson, W. A. Wimsatt, R. Wu, S. A. Zahler, D. B. Zilversmit

Other Teaching Personnel

R. R. Alexander, R. A. Calvo, C. Eberhard, P. R. Ecklund, M. Ferger, J. C. Glase, B. Goodman, J. M. Griffiths, J. B. Heiser, M. V. Hinkle, B. R. Land, T. J. McDonald, C. Reiss, A. H. Savitzky, W. R. Schaffner, M. L. Wilkinson

Distribution Requirement

In the College of Agriculture and Life Sciences, the biological sciences distribution requirement is for a minimum of 9 credits, including at least 6 credits of introductory biology satisfied by Biological Sciences 109–110, or 105–106, or 101–103 plus 102–104. Advanced placement in biology with a score of 4 or 5 (6 or 8 credits, respectively) will satisfy the requirement for introductory biology. The additional credits may be satisfied by any biological sciences courses except Biological Sciences 108, 201, 202, 205, 206, 301, or 302; or by certain other non–biological sciences courses specified by the college.

In the College of Arts and Sciences, the biological sciences distribution requirement is for a two-semester introductory biology sequence satisfied by Biological Sciences 109–110, or 105–106, or 101–103 plus 102–104. Advanced placement in biology with a score of 4 or 5 (6 or 8 credits, respectively) also satisfies the distribution requirement in the biological sciences.

In the College of Human Ecology, the natural sciences distribution requirement is for at least 6 credits selected from Biological Sciences 109–110, 101–103, 102–104, 105–106, or specified courses in chemistry or physics. Advanced placement in biology with a score of 4 or 5 (6 or 8 credits, respectively) also satisfies the distribution requirement in the natural sciences.

Note: Biological Sciences 100, offered during the six-week Cornell Summer Session for 7 credits, also satisfies the distribution requirement.

Biological Sciences 101–102–103–104 should be taken as a unit by students of any college.

Switching from one introductory biology sequence to another at mid-year may *not* be possible due to variation in presentation of topics. Students must receive permission of instructor to switch sequences. Taking sequences in reverse or inconsecutive order is strongly discouraged.

The Major

The Division of Biological Sciences offers a major in biological sciences to students enrolled in either the College of Agriculture and Life Sciences or the College of Arts and Sciences. Before course registration for the junior year, all students must apply for formal admission to the major with the associate director for academic affairs in 118 Stimson Hall. Students in the process of completing the required prerequisites to the major (see below) may be admitted on a provisional basis. Since modern biology has an important physical and quantitative orientation, students are advised to undertake basic science courses that stress this orientation; these courses are signified by the word "recommended" in the listing of requirements below. A 2.75 Cornell cumulative grade point average is required for *final* admission to the major except for those students admitted directly to the major as freshmen (College of Agriculture and Life Sciences students only) or as transfers. In addition, *final* admission to the major requires satisfactory performance in the completion of the following:

1) One year of introductory biology for majors: Biological Sciences 101–103 plus 102–104, or 105–106. Biological Sciences 100, offered during the six-week Cornell Summer Session for 7 credits, also satisfies the introductory biology requirement for majors. Students may choose to accept advanced placement if they have received a score of 5 on the Advanced Placement Examination of the College Entrance Examination Board. Students with a score of 4 must fulfill the introductory biology requirement by taking Biological Sciences 103–104 (or 4 credits of work in Biological Sciences 101–103, or 102–104, or 105–106 selected with the advice and approval of the instructors). Freshmen who have not taken the CEEB examination may register for an advanced standing examination in biology which is administered during fall orientation week.
2) One year of general chemistry: Chemistry 207–208 (recommended), or 215–216 (recommended), or 103–104.
3) One year of college mathematics, including at least one semester of calculus: Mathematics 111–112 (recommended), or 113–112 (recommended), or 105–106, or 111–105, or 113–105.
4) At least one semester of organic chemistry lectures: Chemistry 253, or 357, or 359. (See below for complete organic chemistry requirement for the major.)

Whenever possible, students should include introductory biology, chemistry, and mathematics in their freshman schedule and complete the organic chemistry lecture course in their sophomore year. A student is not encouraged to undertake a major in biological sciences unless performance in the above four subjects gives evidence of capacity to do superior work at a more advanced level.

In addition to the introductory courses in biology, chemistry, and mathematics, each student majoring in biological sciences must complete the following:

1) Organic Chemistry: Chemistry 253 and 251, or 253 and 301, or 357–358 and 251, or 357–358 and 301, or 359–360 and 251, or 359–360 and 301.
2) Physics: Physics 207–208 (recommended), or 112–213–214 (recommended), or 101–102.
3) Genetics: Biological Sciences 281.
4) Biochemistry: Biological Sciences 330 or 331.
5) One of the concentration areas outlined below.
6) The breadth requirement outlined below.
7) As an alternative to 5 and 6 above, the Program in General Biology.
8) Foreign language: Students registered in the College of Arts and Sciences must satisfy the language requirement as stated by that college. Students registered in the College of Agriculture and Life Sciences may satisfy the foreign language requirement of the Division of Biological Sciences by (a) presenting evidence of successful completion of three or more years of study of a foreign language in high school, or (b) attaining a score of 560 or more on the reading portion of the College Entrance Examination Board (CEEB) achievement test, or (c) achieving "qualification" status in a language as defined by the College of Arts and Sciences, or (d) successfully completing at least 6 college credits in a foreign language.

It is recommended that students planning graduate study or pursuing a research career take a course in statistics. Students should consult their faculty advisers when choosing appropriate courses in statistics.

Concentration Areas and Requirements

Students accepted into the biological sciences major must choose a concentration area or the Program in General Biology. The concentration requirements are designed to help students achieve depth in one area of biology while ensuring that the selection of advanced courses will form a coherent and meaningful unit. Due to the flexibility allowed in satisfying these requirements, students should consult their faculty advisers. The possible concentration areas are listed below.

1) *Animal Physiology and Anatomy:* Bio S 274, The Vertebrates; Bio S 316, Cellular Physiology; an introductory animal physiology course (Biological Sciences 311 and 319 or 416 and 418); and at least 4 additional credits selected from the following courses: Bio S 212, Invertebrate Zoology; Bio S 313, Histology: The Biology of the Tissues; Bio S 315 and 317, Ecological Animal Physiology; Bio S 385, Developmental Biology; Bio S 389, Embryology; Bio S 414, Vertebrate Morphology; Bio S 432, Survey of Cell Biology; Bio S 458, Mammalian Physiology; An Sc 427 and 428, Fundamentals of Endocrinology. Students electing to take one of the 3-credit courses (Biological Sciences 212, 315, 385, 414, 432, or An Sc 427) may complete the four credits by taking Bio S 410, Seminar in Anatomy and Physiology.
2) *Biochemistry:* Chemistry 300 or 215–216, Quantitative Chemistry, must be taken. One of the following organic chemistry laboratory sequences must also be taken: Chemistry 301–302, or 251–252–302, or 301, or 251–252. In addition, the student must take a physical chemistry sequence (Chemistry 389-390 or 287–288) and a biochemistry laboratory course (Biological Sciences 638 or 430 or 434). It is recommended that students take the more rigorous organic chemistry and physics sequences (Chemistry 357–358 or 359–360 and Physics 207–208), and a third semester of calculus.

   Students interested in biochemistry should complete a year of introductory chemistry, other than Chemistry 103–104, before the start of their sophomore year. Students are also urged to complete introductory biology in their freshman year.
3) *Botany:* Five courses (including a plant physiology laboratory course) fulfill the concentration requirement, as follows: (a) Bio S 242 and 244 or 341 and 349, Plant Physiology; (b) Bio S 343, Taxonomy of Vascular Plants; (c) either Bio S 345, Plant Anatomy, or Bio S 347, Cytology; and (d) either Bio S 241, Plant Biology; Bio S 348, Phycology; Bio S 444, Comparative and Developmental Morphology of the Embryophyta; Bio S 448, Plant Evolution and the Fossil Record; Bio S 463 and 465, Plant Ecology; or Pl Pa 309, Introductory Mycology. Students are encouraged to take Bio S 499, Undergraduate Research in Biology. A student may elect to complete the required five courses by taking both courses in group (c) rather than taking any in group (d).
4) *Cell Biology:* Chemistry 300 or 215–216, Quantitative Chemistry; a laboratory (Biological Sciences 434 or 430); and one of the following two options:

   Option 1: Bio S 432, Survey of Cell Biology, and 8 additional credits distributed between Groups A and B and approved by the adviser.

   Option 2: Two courses selected from Group A and 6 additional credits distributed between Groups A and B and approved by the adviser.

   Group A: Bio S 433, Cell Structure and Physiology; Bio S 438, Cell Proliferation and Oncogenic Viruses; Bio S 483, Molecular Aspects of Development.

   Group B: Bio S 305, Basic Immunology, Lectures; Bio S 307, Basic Immunology, Laboratory; Bio S 313, Histology: The Biology of the Tissues; Bio S 345, Plant Anatomy; Bio S 347, Cytology; Bio S 485, Microbial Genetics, Lectures; Bio S 486, Immunogenetics; Bio S 496, Cellular Neurobiology; An Sc 419, Animal Cytogenetics; Micro 290, General Microbiology Lectures; Micro 291, General Microbiology Laboratory; Micro 484, Cytology of Prokaryotes Lectures; Micro 485, Cytology of Prokaryotes Laboratory.

   Students interested in cell biology should complete a year of introductory chemistry, other than Chemistry 103–104, before the start of their sophomore year. Students are also urged to complete introductory biology in their freshman year.

   Students anticipating graduate work in cell biology should consider taking a physical chemistry sequence (Chemistry 389–390 or 287–288).
5) *Ecology, Systematics, and Evolution:* Bio S 360, General Ecology; Bio S 477, Organic Evolution; a plant or animal physiology course; and at least one 400-level course with accompanying laboratory from within the concentration offerings. In addition to the latter course, students in this area must select at least two laboratory courses above and beyond those required of all biology majors (i.e., introductory biology, genetics, and organic chemistry). These two laboratory courses may include the physiology course or courses counted toward fulfillment of the breadth requirement, or both. It is strongly recommended that students planning graduate study take a course in statistics (I&LR 210 or 311).
6) *Genetics and Development:* Nine credits, usually selected from the following courses: Bio S 282, Human Genetics; Bio S 347, Cytology; Bio S 385, Developmental Biology; Bio S 389, Embryology; Bio S 446, Cytogenetics; Bio S 477, Organic Evolution; Bio S 481, Population Genetics; Bio S 483, Molecular Aspects of Development; Bio S 484, Molecular Evolution; Bio S 485 and 487, Microbial Genetics; Bio S 486, Immunogenetics; Bio S 499, Undergraduate Research in Biology; Bio S 644, Plant Growth and Development; An Sc 419, Animal Cytogenetics; Pl Br 605, Physiological Genetics of Crop Plants.
7) *Neurobiology and Behavior:* The introductory course in Neurobiology and Behavior (Biological Sciences 321), and 12 additional credits, including a second course from the neurobiology and behavior offerings. Biological Sciences 420, 498, 499, and 720 may *not* be used as the second course. The remainder of the 12 credits may be in any course (such as physiology, developmental biology, cellular biology, ecology, or vertebrate or invertebrate biology) approved by the adviser as appropriate preparation for work or advanced study in neurobiology and behavior or in related subjects. Courses used to fulfill the concentration requirements may *not* be counted toward fulfillment of the breadth requirement.
8) *Independent Option:* Special programs for students interested in biophysics, microbiology (College of Arts and Sciences students only), or nutrition are available under this option. In addition, students who want to undertake a course of study not covered by the seven existing concentration areas, special programs, or the Program in General Biology may petition the Division of Biological Sciences Curriculum Committee. Information on independent options and Curriculum Committee petition forms are available in the Office for Academic Affairs, 118 Stimson Hall.

Breadth Requirement

To fulfill the breadth requirement in the biological sciences major, students must pass a total of two courses outside of their concentration area selected from two of the categories listed below. Students may not count two courses for breadth credit if one course is a prerequisite to the other course. Students should consult their faculty advisers when choosing the courses to meet this requirement.

1) *Animal Physiology and Anatomy:* Biological Sciences 212, 214, 274, 311, 313, 315, 389, 416.
2) *Botany:* Biological Sciences 241, 242 and 244, 341 and 349, 343, 345, 348, 441; Plant Pathology 309.
3) *Cellular and Developmental Biology:* Biological Sciences 305, 347, 385, 432, 483; Microbiology 290.
4) *Ecology, Systematics, and Evolution:* Biological Sciences 260, 360, 364, 471, 472, 475, 476, 477; Entomology 212.
5) *Neurobiology and Behavior:* Biological Sciences 321.

Note: Biological Sciences 385 and 432 may not be used as breadth courses by students concentrating in animal physiology and anatomy.

Biological Sciences 347 may not be used as a breadth course by students concentrating in botany.

Biological Sciences 305, 313, 345, 347, 432, 483, and Microbiology 290 may not be used as breadth courses by students concentrating in cell biology.

Biological Sciences 347, 385, 389, 477, and 483 may not be used as breadth courses by students concentrating in genetics and development.

Biological Sciences 471, 472, 475, or 476 may not be used as a breadth course if Biological Sciences 274 is counted as a breadth course.

Program in General Biology

Students choosing the general biology option must fulfill all the general requirements for the biology major (chemistry, genetics, biochemistry, etc.) *except* one of the concentration areas and the breadth requirement. The specific requirements for the program are:

1) Ecology (Biological Sciences 260 or 360).
2) Neurobiology and Behavior (Biological Sciences 321).
3) A physiology course from the following: Bio S 242 and 244 or 341 and 349, Plant Physiology; Bio S 311, Introductory Animal Physiology, Lectures; Bio S 315, Ecological Animal Physiology, Lectures; Bio S 416, General Animal Physiology: A Quantitative Approach, Lectures.
4) One course from the following: Bio S 212, Invertebrate Zoology; Bio S 241, Plant Biology; Bio S 274, The Vertebrates; Bio S 343, Taxonomy of Vascular Plants; Bio S 348, Phycology; Entom 212, Insect Biology; Micro 290 and 291, General Microbiology.
5) At least one course concentrating on plants. This may be satisfied by a course that also fulfills requirement 3 or 4.
6) At least one course with a laboratory. This may be satisfied by a course that also fulfills requirement 3 or 4 or 5.
7) A biological sciences course offered for 2 or more credits having as a prerequisite one of the following: Bio S 241, Plant Biology; Bio S 242 or 341, Plant Physiology; Bio S 260 or 360, Ecology; Bio S 274, The Vertebrates; Bio S 281, Genetics; Bio S 311, Introductory Animal Physiology, Lectures; Bio S 315, Ecological Animal Physiology, Lectures; Bio S 321, Neurobiology and Behavior; Bio S 330 or 331, Principles of Biochemistry; Bio S 416, General Animal Physiology: A Quantitative Approach, Lectures.

Independent Research and Honors Program

Individual research projects under the direction of a faculty member are encouraged as part of the program of study within a concentration. Applicants for research projects are accepted by the individual faculty members, who take into account students' previous academic accomplishments, interests, and

goals, and the availability of space and equipment suitable for the proposed project. Students accepted for independent research will enroll for credit in Bio S 499, Undergraduate Research in Biology, with the written permission of the faculty supervisor. Any faculty member in the Division of Biological Sciences may act as a supervisor. Faculty supervisors outside the division are acceptable only if a faculty member of the division agrees to take full responsibility for the quality of the work. Information on faculty research activities and undergraduate research opportunities is available in the Behrman Biology Center, G20 Stimson Hall.

Research credits may *not* be used in completion of the following concentration areas: animal physiology and anatomy; biochemistry; botany; cell biology; and ecology, systematics, and evolution. No more than 4 credits of research may be used in completion of the following concentration areas: genetics and development, and neurobiology and behavior.

The honors program in biological sciences is designed to offer advanced training in laboratory or field research through the performance of an original research project under the direct guidance of a member of the faculty. Applications for the honors program are available in the Office for Academic Affairs, 118 Stimson Hall, and must be submitted to the Honors Program Committee by the first week of classes of the senior year. To qualify for the program, students must have completed at least 30 credits at Cornell; have an overall Cornell cumulative grade point average of at least 3.0; and have at least a 3.0 Cornell cumulative grade point average in all biology, chemistry, mathematics, and physics courses. In addition, candidates must have a faculty member to supervise their research. Any faculty member in the Division of Biological Sciences may act as a supervisor. Faculty supervisors outside the division are acceptable only if a faculty member of the division agrees to take full responsibility for the quality of the work. In rare cases, research done elsewhere may be presented for honors, providing that *prior approval* of the Honors Program Committee has been given. An honors candidate usually enrolls for credit in Bio S 499, Undergraduate Research in Biology, under the direction of the faculty member acting as honors supervisor. Participation in an honors research seminar is required. Recommendation to the faculty that a candidate graduate with honors is the responsibility of the Honors Program Committee.

Students interested in the honors program should consult their faculty advisers early during their junior year. Students are encouraged to begin their research projects in their junior year, though students are not formally admitted to the honors program until the beginning of their senior year. Details pertaining to thesis due dates, seminars, and other requirements may be obtained from the chairperson of the Honors Program Committee or the Office for Academic Affairs. Information on faculty research activities and undergraduate research opportunities is available in the Behrman Biology Center, G20 Stimson Hall.

Curriculum Committee

Many decisions pertaining to the curriculum, to division-wide requirements, and to concentration and breadth areas are made by the Curriculum Committee of the division. The committee has faculty and elected student members, and welcomes advice and suggestions from all interested persons.

Advising

Students in need of academic advising or counseling are encouraged to consult their advisers, come to the Behrman Biology Center, G20 Stimson Hall, or contact the associate director for academic affairs, 118 Stimson Hall.

Students interested in marine biology should visit the Cornell Marine Programs Office, G14 Stimson Hall.

Index of Courses

The middle digits of biological sciences course numbers are used to denote courses in specific areas: 0, general; 1, animal physiology and anatomy; 2 and 9, neurobiology and behavior; 3, biochemistry and cell biology; 4, botany; 6 and 7, ecology, systematics, and evolution; 8, genetics and development. The middle digit 5 is used when all other course numbers in a particular area have already been assigned.

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309	201	446	205
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345	204	471	207
347	205	472	207
348	205	473 (new)	212
349	205	474 (new)	207
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363	211	477	207
364	211	478	207
365	211	479 (new)	207
366	211	480 (new)	208
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484	208	656	206
485	208	657	206
486	208	658	202
487	209	660 (new)	207
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496	210	665	207
497	210	666	207
498	201	667	207
499	201	668 (new)	207
600	201	669	207
602	201	670	207
603	201	679	207
604	201	691	210
606	201	695	210
608	201	696	210
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617	202	720	210
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General Courses

101–102 Biological Sciences, Lectures 101, fall; 102, spring. 2 credits each term. Prerequisite: concurrent enrollment in Biological Sciences 103 (fall) or 104 (spring). 101 is prerequisite to 102, unless written permission is obtained from instructor. S-U grades optional, with permission of instructor. May not be taken for credit after Biological Sciences 105–106 or 109–110.

Lecs, M W F 9:05 or 10:10. 2 lecs each week; to accommodate these, students must reserve all 3 days. Evening prelims: fall, Oct. 1 and Nov. 5; spring, Mar. 4 and Apr. 15. K. K. Adler.

Designed both for students who intend to specialize in biological sciences and for those specializing in other subjects, such as the social sciences or humanities, who want to obtain a thorough knowledge of biology as part of their general education. Plant and animal materials are considered together rather than in separate units. The fall semester covers the chemical and cellular basis of life, energy transformations, anatomy, physiology, and behavior. The spring semester covers genetics and development, evolution, ecology, the origin of life, and the diversity of living organisms. Each topic is considered in the light of modern evolutionary theory.

103–104 Biological Sciences, Laboratory 103, fall; 104, spring. 2 credits each term. Prerequisite: concurrent enrollment in Biological Sciences 101 (fall) or 102 (spring), or written permission of instructor. 103 is prerequisite to 104, unless written permission

is obtained from instructor. S-U grades optional, with permission of instructor. No admittance after second week of classes.

Lab, M T W or R 1:25–4:25, M or W 7:30–10:30 p.m., T R or S 8–11, or F 10:10–1:10. One 3-hour lab each week and a weekly lec section for discs, special lecs, etc. To accommodate weekly lec section, students must reserve M W and F 9:05 or 10:10 since the day of the lec section varies throughout the semester. J. C. Glase, P. R. Ecklund, and staff.

A laboratory course emphasizing the methods used by biologists to discover new knowledge. Students design and perform investigations in biology. In preparation for this, exposure is given to basic biological concepts, research methodologies, relevant data analysis techniques and statistics, instrumentation, and laboratory techniques in all of the major areas of biology. Research projects include investigative design, data analysis, and communication of investigative results and conclusions.

105–106 Introductory Biology 105, fall; 106, spring. 4 credits each term (or 2 credits for transfer or advanced placement students, with permission of instructor). Prerequisite: 105 is prerequisite to 106, unless written permission is obtained from instructor. S-U grades optional, with written permission of instructor. May not be taken for credit after Biological Sciences 101–104 or 109–110. Fee, $5.

Lec, M 12:20; disc, 1 hour each week, to be arranged at first lec meeting; additional study and lab hours arranged at student's convenience each week. E. R. Loew, J. M. Calvo, J. M. Bunch.

Designed primarily for students who intend to specialize in the biological or other sciences; also open to nonmajors who want a more comprehensive biology course than the one for nonmajors (Biological Sciences 109–110). Recommended for students whose first language is not English. The course is taught in an autotutorial format and students are expected to put in some time *each* week (students can seldom work ahead and there are severe penalties for falling behind). Laboratory work is an integral part of the course.

Course material is divided into core units that must be completed by all students. Students are expected to achieve greater than 80 percent mastery of required material.

108 Interactive Computing for Students of Biological Sciences Spring. 1 credit. Not open to students with prior courses in computing.

Lec, T 1:25; lec every other week. H. C. Howland.

An introduction to computing using the interactive language BASIC with a discussion of other algebraic computing languages such as FORTRAN. Students are issued tickets for 10 hours of computing time at the Division of Biological Sciences interactive computing facility. Applications to problems in the biological sciences for which microcomputers may be used are emphasized.

109–110 Biology for Nonmajors 109, fall; 110, spring. 3 credits each term. Limited to 600 students. Prerequisite: 109 is prerequisite to 110, unless written permission is obtained from instructor and the student has at least 3 credits of college biology. S-U grades optional (not recommended). May not be taken for credit after Biological Sciences 101–104 or 105–106. This course may be used to fulfill the distribution requirement in the Colleges of Agriculture and Life Sciences, Arts and Sciences, and Human Ecology but may *not* be used as an introductory course for the major in biological sciences. *Note that this course may not always satisfy the prerequisite for second- and third-level courses in biology.*

Lecs, M W F 9:05 or 11:15; lab, M T W R or F 2–4:25 or T 10:10–12:35. Students do not choose lab sections during course enrollment; lab assignments are made during first day of classes. Each student must attend lab on alternate weeks. Evening prelims: fall, Oct. 6 and Nov. 12; spring, Feb. 25 and Apr. 8. Staff.

Students who do not plan to major in biology may take this broad introductory course in modern biology. It is not a course in social biology, but addresses itself to biological principles with academic rigor. The content is designed to appeal to anyone who seeks a comprehensive knowledge of biology as part of a general education. Laboratory sections enable small groups of students to meet with the course staff and are used for problem-solving experiments, demonstrations, and discussions.

200 Special Studies in Biology Fall or spring. 1–3 credits. Prerequisites: written permission of instructor and of the associate director of the Division of Biological Sciences (a special form for this purpose is available in Stimson 118). S-U grades optional, with permission of instructor.

Hours to be arranged. Staff.

For students who want to take only a portion of a regular biological sciences course—for example, only the lectures or only the laboratory in a course that includes both. This course ordinarily is taken only by transfer students who have already had training equivalent to the portion of the regular course that is to be omitted. May not be substituted for 100-level courses.

201–202 History of Biology (also History 287–288) 201, fall; 202, spring. 3 credits each term. Prerequisite: one year of introductory biology. 201 is not prerequisite to 202. S-U grades optional.

Lecs, T R 10:10–11:30. W. B. Provine.

An examination of the history of biology, emphasizing the interaction of biology and culture. Original writings of biologists constitute the bulk of reading assignments. The fall semester covers the period from classical antiquity to 1900. The spring semester is devoted entirely to twentieth-century biology.

205 Biomedical Ethics (also Philosophy 245) Fall. 3 credits. Primarily for sophomores, juniors, and seniors; permission of instructor required for graduate students.

Lecs and discs, M W F 1:25. S. M. Brown.

Critical analysis of the conceptual framework in which ethical problems in biology and medicine are to be understood, debated, and solved. Problems include experimentation on living subjects; reproductive technologies (eugenics, population control); genetic modification; recombinant DNA technology; contraception, abortion, and infanticide; euthanasia and suicide; the allocation of scarce medical resources; physician-patient relationships; and health care systems. Each topic is covered first in a lecture and then, with the assigned readings, made a topic for discussion.

206 Environmental Ethics (also Philosophy 246) Spring. 3 credits. Open to sophomores, juniors, and seniors; permission of instructor required for graduate students. Prerequisite: one year of introductory biology.

Lecs, M W F 1:25. S. M. Brown.

Critical analysis of the conceptual framework in which environmental policies are formulated and judged. Problems include private interest versus the public good; the relation of individual rights to the collective welfare with respect to property, compensation, regulation, and the exercise of eminent domain; moral obligations to the poor and to future generations; the concept of pollution; and the ideas of diversity, balance, and stability in the natural environment.

[208 Biological Discovery Laboratory Spring. 2 credits. Limited to 30 students who apply for admission and are recommended by their instructors in Biological Sciences 103. Prerequisite: Biological Sciences 103. Not offered 1981–82.

Labs, T R 1:25–4:25. Staff.

A research-oriented alternative to Biological Sciences 104. Designed to instruct students in the ways that scientists ask questions about living things and design and carry out observations or experiments to answer these questions. Students work individually on extended research problems that they design. Instruction is highly individualized and aimed at improving each student's ability to ask meaningful questions, organize and quantify observations, analyze research data, and relate results to previously reported biological findings. Written research reports are prepared and oral reports presented. Specific research techniques are introduced when needed.]

300 Laboratory Methods in Biology Summer, 6-week session. 3 credits. Prerequisite: one year of introductory college biology. Fee, $5.

Lecs and labs, M T W R F 1:30–4 for 6 weeks. L. D. Uhler.

For students who intend to teach or follow some phase of biology as a profession. Subjects covered: collection, preservation, and storage of materials; preparation of bird and mammal study skins; injection of circulatory systems with latex; clearing and staining of small vertebrates; and preparation and staining of squashes, smears, whole mounts, and sections. No formal exams. Grade is based on required work submitted at the end of the course.

301 Biology and Society I: The Biocultural Perspective (also Anthropology 301 and Biology and Society 301) Fall. 3 or 4 credits (4 credits by arrangement with instructor). Prerequisite: one year of introductory biology. S-U grades optional. This is part of the two-semester core course for the biology and society major and is also available to other students who have fulfilled the necessary prerequisite.

Lecs, M W F 9:05. D. J. Greenwood.

Human biology, behavior, and institutions are viewed as the ongoing products of the interactions between human biological evolution and cultural change. These interactions are documented with reference to the evolution of the capacity for culture; human groups and institutions; language, meaning, and cultural "realities"; and major models of human nature and human institutions.

302 Biology and Society II: Biology, Society, and Ethics (also Anthropology 302 and Biology and Society 302) Spring. 3 or 4 credits (4 credits by arrangement with instructor). Prerequisite: Biological Sciences 301. S-U grades optional. This is the second semester of the two-semester core course for the biology and society major and is also available to other students who have taken 301.

Lecs, M W F 9:05. D. J. Greenwood, S. J. Risch.

This course considers the complex intellectual, practical, and ethical issues centering on the relationships between biological and social phenomena. Specific current issues such as pollution, genetic counseling, and recombinant DNA research are considered; and an effort is made to develop viable biocultural ethics for dealing with such problems.

305 Basic Immunology, Lectures (also Veterinary Medicine 315) Fall. 2 credits. Recommended: basic courses in microbiology and biochemistry.

Lecs, T R 9:05. Evening prelims: Oct. 8 and Nov. 19. A. J. Winter.

Course material covers current concepts in immunology at an elementary level, with special emphasis on the biological functions of the immune response.

307 Basic Immunology, Laboratory (also Veterinary Medicine 316) Fall. 2 credits. Prerequisite: a course in basic microbiology or permission of instructor. Recommended: concurrent enrollment in Biological Sciences 305.

Labs, T R 10:10–1:10. N. L. Norcross.

Designed to illustrate immunological concepts presented in Biological Sciences 305. Laboratory exercises are selected to familiarize students with basic humoral and cellular immune phenomena and to offer firsthand experience in immunological laboratory techniques.

309 Techniques in Animal Handling and Surgery Intersession. 2 credits. Limited to 12 students, with preference given to students who are registered in an independent research course. Prerequisite: written permission of instructor. S-U grades only. Fee, $5.
Lecs and labs, M T W R F 9–4:30 for 3 weeks.
A. van Tienhoven.
Audiovisual materials and actual experience are used in this minicourse to teach students techniques needed for independent research and honors projects.

498 Teaching Experience Fall or spring. 1–4 credits. Enrollment limited. Prerequisites: previous enrollment in the course to be taught or equivalent, and written permission of instructor. S-U grades optional, with permission of instructor. *Students in the College of Arts and Sciences may not count credits from this course toward the 100 arts college credits required for graduation.*
Hours to be arranged. Staff.
Designed to give qualified undergraduate students teaching experience through actual involvement in planning and assisting in biology courses. This experience may include supervised participation in a discussion group, assisting in a biology laboratory, assisting in field biology, or tutoring. Biological Sciences courses currently offering such experience include Biological Sciences 105–106, 274, 324, 330, 430, 464, 468, and 475.

499 Undergraduate Research in Biology Fall or spring. Variable credit. Prerequisite: written permission from the staff member who will supervise the work and assign the grade. S-U grades optional. Any faculty member in the Division of Biological Sciences may act as a supervisor. Faculty supervisors outside the division are acceptable only if a faculty member of the division agrees to take full responsibility for the quality of the work. *This course is divided into multiple sections as printed in the Course Rosters.* Students must register under supervisor's assigned section number, or section 01 if supervisor was not assigned a section number. Students registering in section 01 should notify the Office for Academic Affairs in Stimson 118.
Hours to be arranged. Staff.
Practice in planning, conducting, and reporting independent laboratory and library research programs.

Research credits may *not* be used in completion of the following concentration areas: animal physiology and anatomy; biochemistry; botany; cell biology; and ecology, systematics, and evolution.

No more than 4 credits of research may be used in completion of the following concentration areas: genetics and development, and neurobiology and behavior.

600 Introduction to Scanning Electron Microscopy Fall or spring, weeks 1–4. 1 credit. Primarily for graduate students, but open to seniors who can demonstrate a need for the course. Limited to 10 students. Prerequisite: permission of instructor. S-U grades only.
Lec and lab to be arranged. M. V. Parthasarathy, M. K. Hausmann.
The course is a general introduction to the principles and the proper use of the scanning electron microscope. Emphasis is on using the instrument to observe biological specimens and on methods of preparing biological material for scanning electron microscopy.

602 Advanced Electron Microscopy for Biologists I Spring, weeks 1–3. 1 credit. Primarily for graduate students. Limited to 8 students. Prerequisites: Biological Sciences 603 or equivalent, and permission of instructor. S-U grades only.
Lec, T 11:15; disc to be arranged; labs, T R 1:25–4:25. M. V. Parthasarathy.
High-resolution electron microscopy; problems of obtaining high-resolution electron micrographs of biological specimens; visualization of macromolecules.

603 Electron Microscopy for Biologists Fall. 3 credits. Primarily for graduate students, but open to upperclass students. Limited to 12 students, with preference given to students with research projects requiring electron microscopy. Prerequisites: either Biological Sciences 300, 313, 345, or 347, or equivalent, and written permission of instructor. Registration during course enrollment recommended. S-U grades optional.
Lec, T 11:15; labs, M W 1:25–4:25, T R 1:25–4:25, or W F 8–11. M. V. Parthasarathy.
Principles of electron microscopy; histological techniques for electron microscopy, such as ultrathin sectioning, negative staining, and metal shadowing; and interpretation of results. A brief introduction to scanning electron microscopy is also included.

604 Advanced Electron Microscopy for Biologists II Spring, weeks 4–6. 1 credit. Primarily for graduate students. Limited to 8 students. Prerequisites: Biological Sciences 603 or equivalent, and permission of instructor. S-U grades only.
Lec, T 11:15; disc to be arranged; labs, T R 1:25–4:25. M. V. Parthasarathy.
Principles of autoradiography at both light microscopy and electron microscopy levels; incorporation of radioactive material into biological specimens for autoradiography; problems of resolution and quantitative aspects of autoradiography.

606 Advanced Electron Microscopy for Biologists III Spring, weeks 7–9. 1 credit. Primarily for graduate students. Limited to 8 students. Prerequisites: Biological Sciences 603 or equivalent, and permission of instructor. S-U grades only.
Lec, T 11:15; disc to be arranged; labs, T R 1:25–4:25. M. V. Parthasarathy.
Principles of freeze fracturing and freeze substitution techniques; freezing artifacts and interpretation of images.

608 Advanced Electron Microscopy for Biologists IV Spring, weeks 10–14. 1 credit. Primarily for graduate students. Limited to 6 students. Prerequisites: Biological Sciences 603 or equivalent, and either Biological Sciences 602, 604, or 606. S-U grades only.
Hours to be arranged. M. V. Parthasarathy.
Project in biological ultrastructure.

702 X-Ray Elemental Analysis in Biology Spring. 1 credit. Limited to 8 students. Prerequisites: Biological Sciences 600 or 603, and permission of instructor. S-U grades only. Offered alternate years.
Lec and lab to be arranged. M. V. Parthasarathy, M. K. Hausmann.
Principles of x-ray elemental analysis are discussed, with special reference to the energy-dispersive system. Emphasis is on qualitative elemental analysis of biological specimens and preparation of material for such analysis. A brief introduction to quantitative elemental analysis is also given.

Related Courses in Other Departments

Biology and Society Senior Seminars (Biology and Society 400–402)

Animal Physiology and Anatomy

[212 Invertebrate Zoology Spring. 3 credits. Limited to 20 students. Prerequisite: one year of introductory biology for majors. Not offered 1981–82.
Lecs, T R 11:15; lab, T 2–4:25. A. W. Blackler.
An introduction to the structure, function, and development of invertebrate animals of the major phyla, with emphasis on the phylogenetic relationships.]

214 Biological Basis of Sex Differences (also Women's Studies 214) Spring. 3 credits. Prerequisite: one year of introductory biology. S-U grades optional.
Lecs and discs, M W F 9:05. J. E. Fortune.
The structural and functional differences between the sexes are examined. Emphasis is placed on mechanisms of mammalian reproduction, and, where possible, special attention is given to studies of humans. Current evidence on the effects of gender on nonreproductive aspects of life (behavior, mental and physical capabilities) is discussed. The course is intended to provide students with a basic knowledge of reproductive endocrinology and with a basis for objective evaluation of sex differences in relation to contemporary life.

274 The Vertebrates Spring. 5 credits. Primarily for sophomores; this course is a prerequisite for many advanced courses in vertebrate biology, anatomy, and physiology. Each lab limited to 21 students. Prerequisite: one year of introductory biology for majors. Fee, $10.
Lecs, T R 10:10; labs, M W 1:25–5, M W 7–10 p.m., or T R 1:25–5. Evening prelim: Mar. 23. Staff.
An introduction to the evolution, classification, comparative anatomy, life history, and behavior of vertebrate animals. Laboratory dissection and demonstration are concerned with structure, classification, systematics, biology of species, and studies of selected aspects of vertebrate life.

311 Introductory Animal Physiology, Lectures (also Veterinary Medicine 346) Fall. 3 credits. Prerequisites: one year of college biology, chemistry, and mathematics. May not be taken for credit after Biological Sciences 416.
Lecs, M W F 11:15. K. A. Houpt and staff.
A general course in vertebrate physiology emphasizing the basic characteristics of the circulatory, nervous, pulmonary, renal, and gastrointestinal systems; energy metabolism; endocrinology; and reproductive physiology. Neural and hormonal control of function is emphasized.

313 Histology: The Biology of the Tissues Fall. 4 credits. Prerequisite: one year of introductory biology. Recommended: background in vertebrate anatomy and organic chemistry or biochemistry.
Lecs, T R 11:15; labs, T R 2–4:25. W. A. Wimsatt.
Provides the student with a basis for understanding the microscopic, fine-structural, and functional organization of vertebrates, as well as the methods of analytic morphology at the cell and tissue levels. The dynamic interrelations of structure, composition, and function in cells and tissues are stressed.

315 Ecological Animal Physiology, Lectures Fall. 3 credits. Prerequisite: one year of introductory biology for majors. Offered alternate years.
Lecs, M W F 10:10. W. N. McFarland and staff.
An introductory course for students interested in ecology and physiology. The characteristics of the physical environment that are important to organisms are discussed; and representative physiological, behavioral, and morphological adaptations of vertebrate and invertebrate animals to their environments are analyzed.

316 Cellular Physiology Spring. 4 credits. Limited to 100 students, with preference given to students concentrating in animal physiology and anatomy. Each lab section limited to 25 students. Prerequisite: concurrent or previous enrollment in Biological Sciences 330 or 331.
Lecs, M W F 9:05; lab, M T W or R 1:25–4:25.
R. A. Corradino and staff.
Lectures introduce students to the most current information on the ways cells regulate themselves and neighboring cells, and on what molecules are involved in these regulatory processes. Laboratories are closely related to lectures and provide practical experience with experiments on such cellular functions as nutrient transport, macromolecular biosynthesis, and cell proliferation.

317 Ecological Animal Physiology, Laboratory Fall. 1 credit. Limited to 24 students. Prerequisite: concurrent enrollment in Biological Sciences 315. Offered alternate years.

Lab, W or R 1:25–4:25. W. N. McFarland.

Exercises involve measurement of important environmental factors in local habitats and laboratory experiments to familiarize students with the use of ecophysiological methods.

319 Introductory Animal Physiology, Laboratory (also Veterinary Medicine 348) Fall. 2 credits. Limited to 100 students, with preference given to students concentrating in animal physiology and anatomy; each lab section limited to 25 students. Prerequisite: concurrent enrollment in Biological Sciences 311, or permission of instructor based on previous meritorious performance in another introductory physiology course. S-U grades optional.

Lab, M T W or R 1:25–4:25; autotutorial preview-disc to be arranged. W. B. Currie.

A series of student-run experiments exposing the objectives, ethics, techniques, and analysis of procedures in systems physiology conducted *in vivo* and *in vitro* with mammals. Students prepare for laboratories in supervised autotutorial sessions with readings and videotapes and are tested before admission to each laboratory. Reports describing the experiments are required. Grading is based on admission tests and evaluation of reports.

351 Biological Rhythms with a Period of One Day to One Year Fall. 1 credit. Prerequisites: one year of introductory biology and either Mathematics 106, 111, or 113.

Lec, R 12:20. A. van Tienhoven.

Theoretical and practical aspects of circadian and circennial rhythms are considered. Selective topics such as the biological clock of plants, insects, and vertebrates are presented. Light is considered as a stimulus and as an entraining agent. The role of rhythms on migration and reproduction is emphasized.

410 Seminar in Anatomy and Physiology Fall or spring. 1 credit. May be repeated for credit only once. Limited to upperclass students. S-U grades only.

Sem to be arranged. Organizational meeting first W of each semester at 7:30 p.m. in Stimson G25. Staff (coordinator: W. Hansel).

412 Special Histology: The Biology of the Organs Spring. 4 credits. Limited to 12 students. Prerequisite: Biological Sciences 313 or written permission of instructor. Offered alternate years.

Lecs, W F 9:05; labs, W F 2–4:25. W. A. Wimsatt.

A continuation of Biological Sciences 313. The microscopic and ultrastructural organization of the principal vertebrate organ systems are studied in relation to their development, functional interaction, and special physiological roles. Courses 313 and 412 together present the fundamental aspects of the microscopic and submicroscopic organization of the vertebrate. The organization of the course involves student participation in lecture-seminars and independent project work supplementary to the regular work of the laboratory. The latter enables students to gain practical experience with histological and histochemical preparative techniques.

414 Vertebrate Morphology (also Veterinary Medicine 700) Spring. 3 credits. Prerequisite: graduate standing, or Biological Sciences 274 or equivalent. (Prerequisite waived for students concentrating in animal physiology and anatomy.) S-U grades optional.

Labs, T R 2–4:25. H. E. Evans.

Student dissections of the dog serve as the basis for a functional consideration of the major component parts of the body and its organ systems. This is followed by a dissection of the cow. Other species (fish to mammal) of interest to members of the class may also be dissected.

416 General Animal Physiology: A Quantitative Approach, Lectures Spring. 3 credits. Prerequisites: one year of college biology and physics. S-U grades optional. May not be taken for credit after Biological Sciences 311.

Lecs, M W F 10:10. H. C. Howland.

The principles of animal physiology are developed through consideration of the functioning of cells, tissues, and organs. Specific topics discussed include respiration, metabolism, circulation, excretion, body mechanics, muscle contraction, nerve action, sensory reception, and central nervous system function. A quantitative, systems-theoretical approach is emphasized.

418 General Animal Physiology, Laboratory Spring. 2 credits. Prerequisite: concurrent enrollment in Biological Sciences 416 or equivalent.

Lec, W 7:30 p.m.; lab, M or W 1:25–4:25. H. C. Howland.

Students are introduced to basic techniques utilized in the study of the physiology of animal tissues. Experiments cover topics dealing with respiration, properties of muscle, circulation, activity of nerves, and osmotic phenomena.

452 Comparative Physiology of Reproduction of Vertebrates, Lectures (also Animal Science 452) Spring. 3 credits. Prerequisite: Animal Science 427 or permission of instructor.

Lecs, M W F 1:25. A. van Tienhoven.

Sex and its manifestations. Neuroendocrinology, endocrinology of reproduction, sexual behavior, gametogenesis, fertilization, embryonic development, care of the zygote, environment and reproduction, and immunological aspects of reproduction.

454 Comparative Physiology of Reproduction of Vertebrates, Laboratory (also Animal Science 454) Spring. 2 credits. Prerequisite: concurrent or previous enrollment in Biological Sciences 452 or permission of instructor.

Lab to be arranged. Organizational meeting first F of semester at 2:30. A. van Tienhoven.

The laboratory provides students with an opportunity to independently design and execute experiments with limited objectives.

458 Mammalian Physiology Spring. 6 credits. Enrollment limited. Prerequisite: Biological Sciences 311 or 416, or equivalent with written permission of instructor.

Lecs, M W F 8; lab, M or W 1:25–4:25; 4 additional hours to be arranged. K. W. Beyenbach and staff.

Selected topics in mammalian physiology are discussed in the lecture and concurrently studied in the laboratory. Topics are selected from the following: physiology of membranes and epithelia; nerve and muscle; heart and circulation; autonomic, somatic, and sensory nervous systems; respiration; digestion; salt and water balance; acid-base balance; and endocrine regulation.

610 Mammalian Neurophysiology (also Veterinary Medicine 753) Spring. 3 credits. Limited to 16 students. Prerequisites: two years of college biology. Recommended: courses in biochemistry and physics. Offered alternate years.

Lec and disc, R 10:10; lab, R 1:25–4:25; additional hours to be arranged. E. L. Gasteiger.

Studies include electrical activity of cells; reflexes; decerebrate rigidity; acoustic microphonic response; subcortical stimulation; and evoked and spontaneous cortical activity.

[615 Nutrition and Physiology of Mineral Elements (also Veterinary Medicine 759 and Nutritional Sciences 659) Fall. 2 credits. Prerequisites: courses in basic physiology, intermediate biochemistry, and general nutrition. Offered alternate years. Not offered 1981–82.

Lecs, T R 10:10. R. Schwartz, D. R. Van Campen, R. H. Wasserman.

Lectures on nutritional aspects and physiological, biochemical, and hormonal relationships of the prominent macroelements and microelements, with emphasis on recent developments. Information is included on methodologies of mineral research and the essentiality, requirements, transport, function, homeostasis, interrelationships, and toxicity of various mineral elements.]

616 Radioisotopes in Biological Research (also Veterinary Medicine 750) Spring. 4 credits. Prerequisites: courses in animal or plant physiology, or permission of instructor.

Lecs, T R 11:15; lab, T 1:25–5. F. W. Lengemann.

Lectures and laboratories deal with the radioisotope as a tool in biological research. Among the topics considered are the utilization and detection of beta-emitting isotopes, gamma spectrometry, Cerenkov counting, neutron activation, autoradiography, and isotope dilution. Emphasis is placed on liquid scintillation counting, double-label experiments, and C^{14} and H^3 as metabolic tracers. Experiments are designed to present basic principles, using plants and animals as subject material.

617 Applied Electrophysiology (also Veterinary Medicine 652) Fall. 2 credits. Open to seniors, graduate students, and second-, third-, and fourth-year veterinary students. Prerequisites: physics and two years of college biology; or permission of instructor.

Lec, W 8; lab, W 2–4:25. E. L. Gasteiger, E. R. Loew.

Theory and practice of electrophysiological techniques currently used for study of the nervous and muscular systems in normal and diseased states. Topics include electroencephalography, electromyography, electroretinography, and evoked potentials.

[618 Biological Membranes and Nutrient Transfer (also Veterinary Medicine 752) Spring. 2 credits. Prerequisites: courses in animal or plant physiology, quantitative and organic chemistry, and physics, and permission of instructor. Recommended: courses in cellular physiology and elementary physical chemistry. S-U grades optional, with permission of instructor. Offered alternate years. Not offered 1981–82.

Lecs, T R 11:15. R. H. Wasserman.

An introduction to elementary biophysical properties of biological membranes; theoretical aspects of permeability and transport; and mechanism of transfer of inorganic and organic substances, primarily across epithelial membranes.]

[619 Lipids (also Nutritional Sciences 602) Fall. 2 credits. Prerequisite: Biological Sciences 330 or 331. Not offered 1981–82.

Lecs, T R 11:15. A. Bensadoun.

Advanced course on biochemical, metabolic, and nutritional aspects of lipids. Emphasis on critical analysis of current topics in lipid methodology; lipid absorption; lipoprotein secretion, structure, and catabolism; mechanism of hormonal regulation of lipolysis and fatty acid synthesis; and cholesterol metabolism and atherosclerosis.]

658 Molecular Mechanisms of Hormone Action (also Veterinary Medicine 758) Spring. 2 credits. Prerequisite: permission of instructor. Offered alternate years.

Lecs, T R 10:10. R. A. Corradino.

An advanced course developed from the current literature on endocrine mechanisms.

719 Graduate Research in Animal Physiology and Anatomy (also Veterinary Medicine 600) Fall or spring. Variable credit. Prerequisite: written permission of section chairperson and staff member who will supervise the work and assign the grade. S-U grades optional.

Hours to be arranged. Staff.

Similar to Biological Sciences 499 but intended for graduate students who are working with faculty members on an individual basis.

Related Courses in Other Departments

Adaptations of Marine Organisms (Biological Sciences 413)

Advanced Work in Animal Parasitology (Veterinary Medicine 737)

Anatomy and Behavior of the Gull (Biological Sciences 312)

Animal Reproduction and Development (Animal Science 220)

Cellular Neurobiology (Biological Sciences 496)

Developmental Biology (Biological Sciences 385)

Embryology (Biological Sciences 389)

Fundamentals of Endocrinology (Animal Science 427–428)

Insect Morphology (Entomology 322)

Integration and Coordination of Energy Metabolism (Biological Sciences 637)

Neuroanatomy (Veterinary Medicine 504)

Parasitic Helminthology (Veterinary Medicine 440)

Population Biology of Health and Disease (Veterinary Medicine 330)

Teaching Experience (Biological Sciences 498)

Undergraduate Research in Biology (Biological Sciences 499)

Vision (Biological Sciences 395)

Biochemistry and Cell Biology

132 Orientation Lectures in Biochemistry
Spring, weeks 1–3. Noncredit. Primarily for freshmen, sophomores, and transfer students. S-U grades only (registered students receive an unsatisfactory grade for nonattendance).
Lec, S 10:10–11:30; first 3 Saturdays of semester. Section chairperson and staff.
Lectures illustrate modern research and training in biochemistry and molecular and cell biology.

231 General Biochemistry Fall. 3 credits.
Intended for students who have not previously studied biochemistry and who do not expect to pursue it further. Not recommended for students who have taken organic chemistry. Prerequisite: Chemistry 104 or 208 or equivalent. S-U grades optional.
Lecs, M W F 12:20. J. M. Griffiths.
A brief introductory section relating organic chemistry to biochemistry is given, followed by the biochemical material in the usual one-semester introductory courses. Topics of general interest are also included.

330–331 Principles of Biochemistry Introductory biochemistry is offered in two formats: individualized instruction (330) and lectures (331). *Individualized instruction is offered to a maximum of 150 students each semester. Lectures given fall semester only.*

330 Principles of Biochemistry, Individualized Instruction Fall or spring. 4 credits. Prerequisite: Chemistry 253 or 358 or equivalent. May not be taken for credit after Biological Sciences 331.
Discs, M W F 8 or 10:10; additional hours to be arranged. No formal lecs. Fall: M. Ferger and staff; spring: M. Ferger, R. Wu, and staff.
The focal point for this course is a study center—open mornings, afternoons, and some evenings—where students find materials, get help, participate in discussions, and take exams. Students are required to master a minimum body of core material. The pace at which this material is assimilated is largely self-determined. Students who want to go beyond core material have available a wide range of electives, including discussions of research papers and independent study of a variety of problems and *Scientific American* articles. Grades are determined primarily by the amount of elective work satisfactorily completed and by a final exam.

331 Principles of Biochemistry, Lectures Fall; also offered during the 6-week summer session. 4 credits. Prerequisite: Chemistry 253 or 358 or equivalent. May not be taken for credit after Biological Sciences 330.
Lecs, M W F S 10:10. B. K. Tye, J. K. Moffat, R. Barker.
Chemistry of biological substances, presented in a lecture format. Course content is similar to that of Biological Sciences 330.

430 Basic Biochemical Methods Fall or spring. 4 credits. Enrollment limited. Prerequisites: Biological Sciences 330 or 331, a lab course in organic chemistry, and permission of instructor.
Lec and disc, F 1:25; labs, M W or T R 12:20–4:25. R. R. Alexander, J. M. Griffiths, M. L. Wilkinson.
A modular course designed to introduce the student to the biochemical techniques most commonly used in various biological fields. Students select two of the following modules: clinical and nutritional biochemistry, lipids, isolation and characterization of cell components, or nucleic acids. An enzymology module is taken by all students.

432 Survey of Cell Biology Spring; also offered during the 3-week summer session. 3 credits. Prerequisite: Biological Sciences 330 or 331 or equivalent.
Lecs, M W F 11:15. J. T. Lis, M. V. Hinkle, and staff.
A survey of material covered in depth in Biological Sciences 433, 438, and 483. The course covers a wide array of topics, including microscopic techniques, membrane activities, cell junctions, organelles, cell movement, cell division, chromosome structure and the control of gene expression, and cellular differentiation.

[433 Cell Structure and Physiology Fall. 2 credits. Prerequisite: Biological Sciences 330 or 331 or permission of instructor. Not offered 1981–82.
Lecs, T R 12:20. R. E. MacDonald.
The functional aspects of cells and their organelles: bioenergetics, transport, movement, growth, nutrition, and structure are examined in detail in free-living cells, differentiated cells, and highly specialized cells. The course attempts to integrate current knowledge about cell biochemistry, structure, and function with the role of the cell in its environment and in its interrelationship with other cells.]

434 Laboratory in Cell Biology Spring. 4 credits. Enrollment limited. Prerequisite: written permission of instructor.
Labs, M W 1:25–4:25 or R 9:05–4:25; disc to be arranged. J. Gibson.
The course provides experience in experimental design and stresses techniques for handling and experimenting with cells of different kinds.

435–436 Undergraduate Biochemistry Seminar 435, fall; 436, spring. 1 credit each term. May be repeated for credit. Enrollment limited; upperclass students only. Prerequisite: Biological Sciences 330 or 331, or written permission of instructor. S-U grades optional, with permission of instructor.
Sem to be arranged. Organizational meeting first W of each semester at 4 p.m. Fall: D. B. Wilson; spring: R. E. McCarty.
A group of selected papers from the literature are critically evaluated during six or seven two-hour meetings. Fall: the role of genetic engineering in the study of genetic control mechanisms; spring: photosynthesis.

438 Cell Proliferation and Oncogenic Viruses
Spring. 2 credits. Prerequisite: Biological Sciences 330 or 331. Recommended: Biological Sciences 281.
Lecs, T R 12:20. V. M. Vogt.
A description of the growth properties of animal cells in culture, followed by discussions of the changes in cells that are induced by tumor viruses and carcinogens. Topics include macromolecular growth factors, contact inhibition, cell surface properties, cell cytoskeleton, transcription and translation of viral and host genes, and integration of viral DNA into host chromosomes.

[456 Molecular Biology of Yeast Spring. 3 credits. Prerequisites: Biological Sciences 281 and a course in organic chemistry. Not offered 1981–82; first offered spring 1983.
Lecs, M W F 9:05. G. R. Fink.
Saccharomyces cerevisiae, a single-celled lower eucaryote, possesses physiological, biochemical, and genetic characteristics that make it an ideal organism for investigating many fundamental aspects of gene expression in eucaryotes. These characteristics are discussed, together with current research methodologies (tetrad analysis, fine structure mapping, mutant isolation, transformation, and recombinant DNA techniques) and their application in understanding phenomena such as cell division and determination of mating type.]

631 Protein Structure and Function Fall. 2 or 3 credits (3 credits with discussion). Prerequisites: introductory biochemistry, physical chemistry, and organic chemistry; or permission of instructor. S-U grades optional, with permission of instructor.
Lecs, M W 9:05; disc, F 9:05. G. W. Feigenson and staff.
Lectures on protein structure and the nature of enzymatic catalysis. Discussions cover some of these areas in more depth, through recent research papers.

632 Bioenergetics and Membranes Spring. 2 credits. Prerequisites: Biological Sciences 330 or 331, and either Chemistry 358 or 360; or written permission of instructor. Recommended: physical chemistry.
Lecs, T R 11:15. P. C. Hinkle.
Oxidative phosphorylation, photophosphorylation, active transport, muscle contraction, and the structure of biological membranes.

633 Biosynthesis of Macromolecules Fall. 2 credits. Prerequisite: Biological Sciences 330 or 331.
Lecs, T R 9:05. J. W. Roberts, D. B. Wilson.
DNA, RNA, and protein synthesis; regulation of gene expression; and other topics.

634 Biochemistry of the Vitamins and Coenzymes (also Nutritional Sciences 634)
Spring. 2 credits. Prerequisites: Biological Sciences 330 or 331 or equivalent, and either Chemistry 358 or 360. Offered alternate years.
Lecs, T R 10:10. M. N. Kazarinoff.
The chemical, biochemical, and nutritional aspects of the vitamins and coenzymes.

635 Metabolic Regulation (also Nutritional Sciences 635) Spring. 2 credits. Prerequisites: Biological Sciences 330 or 331, and either Chemistry 358 or 360; or written permission of instructor. Recommended: physical chemistry.
Lecs, T R 9:05. W. L. Dills and staff.
The study of enzymes and the molecular mechanisms of metabolic regulation.

637 Integration and Coordination of Energy Metabolism (also Nutritional Sciences 636) Fall. 3 credits. Prerequisite: Biological Sciences 330 or 331 or equivalent.
Lecs, M W F 9:05. Evening prelims: Sept. 24, Oct. 22, and Nov. 19. W. J. Arion and staff.
The elements of caloric homeostasis are developed through correlations of the structural, functional, and metabolic characteristics of the major animal tissues and organs. Mechanisms that control energy metabolism within individual tissues and coordinate these processes in the intact animal are analyzed in the contexts of selected physiologic and pathologic stresses.

638 Intermediate Biochemical Methods Spring. 4 credits. Primarily for undergraduates majoring in biochemistry and for graduate students with a minor in biochemistry. Prerequisites: Biological Sciences 330 or 331, and permission of instructor. Undergraduates must obtain permission of instructor by the last day of the course enrollment period.
Lab, T or R 9:05–4:25. A lab section is also scheduled W 9:05–4:25, if enrollment requires it. E. B. Keller, L. A. Heppel, and staff.
Selected experiments on proteins, enzymes, DNA, and bioenergetics to illustrate basic biochemical principles. The course emphasizes quantitative aspects and techniques currently used in biochemical research.

732–738 (731–739) Current Topics in Biochemistry Fall or spring. ½ or 1 credit for each topic. May be repeated for credit. (Students registering for ½ credit should *not* fill in the credit-hour column on the optical mark registration form; the computer is programmed to automatically register students for ½ credit.) Prerequisite: Biological Sciences 330 or 331 or equivalent. S-U grades only.

Lectures and seminars on specialized topics.

Fall 1981: three topics are offered.

733 Plastid Biogenesis ½ credit.
T R 12:20 (6 lecs); Sept. 8–24. A. T. Jagendorf.

735 Molecular Basis of Sickle Cell Disease ½ credit.
T R 12:20 (6 lecs); Sept. 29–Oct. 15.
S. J. Edelstein.

737 Chemical Carcinogenesis ½ credit.
T R 12:20 (6 lecs); Oct. 27–Nov. 12.
T. C. Campbell.

Spring 1982: four topics are offered.

732 Crystallography of Macromolecules ½ credit.
T R 12:20 (6 lecs); Feb. 2–18. J. K. Moffat.

734 Nuclear Magnetic Resonance (NMR) of Macromolecules 1 credit.
W F 12:20 (12 lecs); Feb. 3–Mar. 12.
G. W. Feigenson.

736 Proteases in Regulation ½ credit.
T R 12:20 (6 lecs); Apr. 6–22. J. F. Wootton.

738 Cloning and Structural Analysis of Genes ½ credit.
W F 12:20 (6 lecs); Apr. 21–May 7. R. Wu.

830 Biochemistry Seminar Fall or spring. Noncredit.
Sem, F 4:15. Staff.
Lectures on current research in biochemistry, presented by distinguished visitors and staff members.

831 Advanced Biochemical Methods I Fall. 6 credits. Limited to graduate students majoring in biochemistry.
Labs and discs, 12 hours each week to be arranged. Organizational meeting first R of semester at 10:10. D. B. Wilson and staff.
To learn the basic techniques of biochemical research, each student completes a set of experiments.

832 Advanced Biochemical Methods II Spring. 6 credits. Limited to graduate students majoring in biochemistry. S-U grades only.
Lab to be arranged. Staff (coordinator: J. K. Moffat).
Research in the laboratories of three different professors chosen by the student. Arrangements are made jointly between the field representative and the research adviser.

833 Research Seminar in Biochemistry Fall and spring. 1 credit each term. (Students must register for 2 credits each term, since an "R" grade is given at the end of the fall term.) May be repeated for credit. Required of all graduate students (first-year students excepted) majoring in biochemistry. S-U grades only.
Sem, M 7:30–9 p.m. E. Racker, V. M. Vogt, J. K. Moffat.

Related Courses in Other Departments

Lipids (Biological Sciences 619)

Molecular Aspects of Development (Biological Sciences 483)

Molecular Mechanisms of Hormone Action (Biological Sciences 658)

Plant Biochemistry (Biological Sciences 648)

Teaching Experience (Biological Sciences 498)

Undergraduate Research in Biology (Biological Sciences 499)

Botany

241 Plant Biology Fall. 3 credits. Enrollment may be limited, with preference given to sophomores and juniors majoring in agronomy, botany, environmental education, floriculture, horticulture, natural resources, plant sciences, vegetable crops, and wildlife. Prerequisite: one year of introductory biology for majors or equivalent.
Lecs, T R 9:05; lab, M T W R or F 1:25–4:25, or M or W 7:30–10:30 p.m. Evening prelims: Oct. 15 and Nov. 19. K. J. Niklas.
Introductory botany for those who plan to specialize in or use some aspect of the plant sciences. Emphasizes structure reproduction, and classification of angiosperms and the history of life on earth. Laboratory emphasizes development of skills in handling plant materials, including identification. First and second weeks of laboratory are field trips, starting with the first day of classes. *Those who register for an evening laboratory are still required to attend the afternoon field trips.*

242 Plant Physiology, Lectures Spring. 3 credits. Primarily for undergraduates in agricultural sciences. Prerequisites: one year of introductory biology and introductory chemistry; concurrent enrollment in Biological Sciences 244 or written permission of instructor required for undergraduates. May not be taken for credit after Biological Sciences 341, unless written permission is obtained from instructor.
Lecs, M W F 10:10. P. J. Davies.
Plant physiology as applied to plants growing in communities. Examples deal with crop plants or higher plants where possible, though not exclusively. Topics include cell structure and function; plant metabolism, including photosynthesis; soil-plant-water relations; water uptake, transport, and transpiration; irrigation of crops; sugar transport; mineral nutrition of crops; respiration and photosynthesis; light relations in crops; growth and development—hormones, flowering, fruiting, dormancy, and abscission; and chemical control of plant growth.

244 Plant Physiology, Laboratory Spring. 2 credits. Prerequisite: concurrent enrollment in Biological Sciences 242. May not be taken for credit after Biological Sciences 349.
Lab, M T W or R 1:25–4:25; disc, M T W or R 12:20. Lab and disc must be on same day. C. Reiss.
Experiments exemplify concepts covered in Biological Sciences 242 and offer experience in a variety of biological and biochemical techniques, including use of radioisotopes.

246 Ethnobotany Spring. 3 credits. Limited to 20 students. Prerequisite: written permission of instructor.
Lecs, M W 8; lab, F 2–4:25. D. M. Bates.
A consideration of the role of plants in primitive and lay societies, with emphasis on the nature of the plant resource base, the manner in which man uses this base, and the extent to which it enters his folklore and has influenced his cultural development. Laboratories provide a practical introduction to the plant kingdom by stressing plant organization and identification and plant crafts.

247 Poisonous Plants Fall. 2 credits. S-U grades optional.
Lecs, T R 9:05. J. M. Kingsbury.
A discussion of incidence and conditions of poisoning in man and animals, poisonous principles from plants, and effects of toxic plants on vertebrates.

341 Plant Physiology, Lectures Fall. 3 credits. Prerequisites: one year of introductory biology, organic chemistry, and either concurrent enrollment in Biological Sciences 349 or written permission of instructor. May not be taken for credit after Biological Sciences 242, unless written permission is obtained from instructor.
Lecs, T R 10:10 and M 7:30 p.m. A. T. Jagendorf.
The behavior, growth, transport processes, and environmental response of plants. Topics include membrane properties, solute and water transport, and function of osmotic forces; mineral and organic nutrition; stress resistance; growth and hormonal action; metabolism, including photosynthesis and respiration; and responses to gravity, light, photoperiod, and temperature.

342 Taxonomy of Cultivated Plants (also Floriculture and Ornamental Horticulture 342) Spring. 4 credits. Limited to 28 students. Prerequisite: one year of introductory biology or written permission of instructor. May not be taken for credit after Biological Sciences 343.
Lecs, M W 10:10; labs, M W 2–4:25. J. W. Ingram.
A study of ferns and seed plants, their relationships, and their classification into families and genera, emphasizing cultivated plants. Particular emphasis is placed on gaining proficiency in identifying and distinguishing families and in preparing and using analytical keys. Attention is also given to the economic importance of taxa, to the basic taxonomic literature, and to the elements of nomenclature.

343 Taxonomy of Vascular Plants Fall. 4 credits. Prerequisites: one year of introductory biology and written permission of instructor. May not be taken for credit after Biological Sciences 342.
Lecs and discs, T R 9:05; labs, T R 2–4:25. M. D. Whalen.
An introduction to the classification of ferns and flowering plants, with attention to principles, methods of identification, and literature. Field trips are held during laboratory periods in the first half of the term.

345 Plant Anatomy Fall. 4 credits. Limited to 48 students. Prerequisite: one year of introductory biology or a semester of botany. Not intended for general education. Students in doubt about their level

of preparedness or the role of this course in their curricula are encouraged to consult the instructor before registering.
Lecs, T R 8; labs, M W 2–4:25 or T R 10:10–12:35. D. J. Paolillo.
A descriptive course with equal emphasis on development and mature structure. Lecture, laboratory, and reading are integrated in a study guide. The laboratory offers the opportunity to develop the practical skills required to make anatomical diagnoses and to write anatomical descriptions.

347 Cytology Fall. 4 credits. Prerequisite: one year of introductory biology for majors. Recommended: Biological Sciences 281.
Lecs, M W 9:05; labs, M W or T R 10:10–12:35. C. H. Uhl.
A study primarily of the structure of cells and their components, and the relation of these to function and heredity. Special attention is given to chromosomes. Both plant and animal materials are used.

[348 Phycology Spring. 4 credits. Not offered 1981–82.
Lecs, M W F 10:10; lab, M W or F 2–4:25. J. M. Kingsbury.
An introduction to freshwater and marine algae, including consideration of their ecology as members of the plankton and benthos and their importance to man. The laboratory uses field material and cultures from an extensive living collection to illustrate lecture topics, provide familiarity with algae in the field, and introduce the student to techniques used in isolating, culturing, and studying algae in the laboratory.]

349 Plant Physiology, Laboratory Fall. 2 credits. Prerequisite: concurrent enrollment in Biological Sciences 341. May not be taken for credit after Biological Sciences 244.
Lab, T W or R 1:25–4:25; disc, T W or R 12:20. Lab and disc must be on same day. C. Reiss.
Experiments exemplify concepts covered in Biological Sciences 341 and offer experience in a variety of biological and biochemical techniques, including use of radioisotopes.

[440 Plant Geography Spring. 2 credits. Prerequisite: Biological Sciences 343 or equivalent. Recommended: Biological Sciences 463 or 477 or both. S-U grades optional, with permission of instructor. Offered alternate years. Not offered 1981–82; first offered spring 1983.
Lecs, T R 10:10. M. D. Whalen.
Patterns of distribution and variation of plant species and higher taxa; endemism and disjunction and their causes; influences of past continental movements and climatic change on plant distributions; geographical aspects of plant speciation; major biomes and floristic regions of the world; and methods of phytogeographic analysis.]

442 Biology of Plant Species Spring. 2 credits. Prerequisite: Biological Sciences 343 or equivalent. Recommended: Biological Sciences 463 or 477 or both. S-U grades optional, with permission of instructor. Offered alternate years.
Lecs, T R 10:10. M. D. Whalen.
A comprehensive introduction to the nature and origin of plant species, with coverage of plant evolutionary genetics, race formation and modes of speciation, evolution of reproductive isolating mechanisms, types of species complexes found in plants, cytogenetic aspects of plant speciation, natural hybridization and its consequences, and the origin and nature of higher taxa.

[443 (442) Research Methods in Systematic Botany Fall. 2 credits. Limited to 10 students. Prerequisite: Biological Sciences 343 or equivalent. Offered alternate years. Not offered 1981–82; first offered fall 1982.
Lab, F 1:25–4:25; additional hours to be arranged. Bailey Hortorium staff.
An introduction to the methodology of plant systematic research: field studies; sampling and collecting methods; preparation of taxonomic revisions and monographs; numerical methods of data analysis; and laboratory methods in cytogenetics, comparative anatomy, and comparative chemistry, as applied to problems in plant systematics.]

[444 Comparative and Developmental Morphology of the Embryophyta Spring. 4 credits. Prerequisite: Biological Sciences 345. Offered alternate years. Not offered 1981–82.
Lecs, T R 8; labs, T R 2–4:25. D. J. Paolillo.
The life histories of bryophytes, vascular cryptograms, and seed plants are examined for their developmental attributes and for their bearing on concepts of evolution and group relationships. The course content is designed to develop an awareness of the integration between morphology and other disciplines in biology.]

445 Photosynthesis (also Engineering A&EP 601) Fall. 3 credits. Prerequisites: Chemistry 104 or 208; Mathematics 106, 111, or 113; and either Physics 102 or 208; or permission of instructor. Offered alternate years.
Lecs, M 1:25 and T R 10:10. R. K. Clayton.
A detailed study of the process by which plants use light in order to grow; physical and physicochemical aspects of the problem are emphasized.

[446 Cytogenetics Spring. 3 credits. Prerequisites: Biological Sciences 281 and 347, or their equivalents. Offered alternate years. Not offered 1981–82.
Lecs, M W 9:05; lab, M or W 10:10–12:35. C. H. Uhl.
Deals mainly with the cellular mechanisms of heredity, including recent research in cytology, cytogenetics, and cytotaxonomy.]

448 Plant Evolution and the Fossil Record Spring. 3 credits. Prerequisite: Biological Sciences 241 or equivalent, or written permission of instructor. Offered alternate years.
Lecs, T R 9:05; lab, R 12:20–2:15. K. J. Niklas.
An introduction to evolution, surveying major changes in plants from the origin of life to the present. Emphasis is placed on plant form and function, adaptations to particular ecologic settings, and evolutionary theory as it relates to plants.

640 Applied Plant Anatomy Spring. 3 credits. Prerequisites: Biological Sciences 345 or equivalent, and permission of instructor.
Lecs and discs, T R 9:05; lab, W 1:25–4:25. N. W. Uhl.
The use of anatomy in vascular plants for diagnosis of structure, taxonomic relationships, evolutionary sequences, and ecological adaptions with emphasis on recent research. The laboratory provides experience in techniques and interpretation.

[642 Topics in Ultrastructure of Plant Cells Spring. 3 credits. Primarily for graduate students, although upperclass students with adequate background are allowed to enroll. No auditors. Prerequisites: Biological Sciences 345 or 347, and written permission of course coordinator. Offered alternate years. Not offered 1981–82.
Lecs, M W F 10:10; optional disc, F 1:25 or to be arranged. Staff (coordinator: M. V. Parthasarathy).
An advanced course dealing with organelles in depth, and in breadth where necessary. Topics include salient ultrastructural features of some plant groups and certain specialized cells and processes. Content of the course and staff direction vary to some extent from year to year.]

643 Plant Physiology, Advanced Laboratory Techniques Fall. 4 credits. Primarily for graduate students doing work in plant physiology, but open to others if space permits. Prerequisites: organic chemistry, biochemistry, and a course in plant physiology. S-U grades only.
Lab, T or W 8–5; disc, M 4:30–5:30. A. T. Jagendorf and staff.
An introduction to some modern methods in experimental plant biology.

644 Plant Growth and Development Spring. 3 credits. Prerequisites: Biological Sciences 345 and either 242 or 341, or their equivalents; or written permission of instructor. Offered alternate years.
Lecs, M W F 9:05. P. J. Davies, D. J. Paolillo.
Explores the changes that occur during plant growth and development and their control: morphological and anatomical changes in apices, tissue differentiation, organ formation, embryo development, gene regulation, hormone action and interaction, the influence of light in development, flowering, fruiting, dormancy, abscission, and senescence.

645 Families of Tropical Flowering Plants Fall. 1 credit. Prerequisite: written permission of instructor. S-U grades only. Offered alternate years.
Lec and disc, F 11:15. D. M. Bates.
The families of flowering plants encountered solely or chiefly in tropical regions are considered in lectures, discussions, and demonstrations, with the aim of providing basic points of recognition for, and an understanding of, diversity and relationships in these families for the student venturing into the tropics.

[646 Families of Tropical Flowering Plants: Field Laboratory Intersession. 3 credits. Limited to 20 students, with preference given to seniors and graduate students from member institutions of the Organization for Tropical Studies. Prerequisite: Biological Sciences 342 or 343 or equivalent. Recommended: Biological Sciences 645. S-U grades only. For more details and application, contact the L. H. Bailey Hortorium, 467 Mann Library. Estimated cost of tuition plus room and board (exclusive of transportation), $1,000. Offered alternate years. Not offered 1981–82.
Bailey Hortorium staff.
An intensive orientation to families of tropical flowering plants represented in forests of the American tropics. Emphasis on field identification combined with laboratory analysis of available materials in a "whole-biology" context.]

647 Seminar in Systematic Botany Spring. 1 credit. May be repeated for credit. Prerequisite: written permission of course coordinator required for undergraduates. S-U grades optional.
Sem to be arranged. Organizational meeting first F of semester at 1:25. Staff (coordinator: D. M. Bates).
Lectures and discussions led by staff, visitors, and students on topics of current importance to systematic botany.

[648 Plant Biochemistry Spring. 3 credits. Prerequisites: organic chemistry, biochemistry, and a course in plant physiology. Offered alternate years. Not offered 1981–82.
Lecs, M W F 9:05. A. T. Jagendorf, R. E. McCarty, J. F. Thompson.
Selected areas of plant biochemistry are reviewed in the context of the plant life cycle and responses to the environment. Topics include metabolism of lipids, carbohydrates, organic acids, and proteins; nitrogen and sulfur assimilation; respiration; photosynthesis; development and replication of chloroplasts; and cell wall composition and properties. Attention is paid to operation of control mechanisms.]

[649 Transport of Solutes and Water in Plants Fall. 3 credits. Prerequisite: Biological Sciences 341 or equivalent. Offered alternate years. Not offered 1981–82.
Lecs, M W F 10:10. R. M. Spanswick.
Transport of ions, water, and organic materials in plants; mechanisms of ion transport; relationships between ion transport and metabolism; ion uptake and transport in higher plants; phloem transport; and water relations of single cells and whole plants.]

[651 Quantitative Whole-Plant Physiology Fall. 3 credits. Prerequisites: introductory physics, calculus, and plant physiology. S-U grades only. Offered alternate years. Not offered 1981–82.
Lecs, T R 10:10–11:30. R. M. Spanswick.
An exploration of the extent to which physiological processes and their interactions can be formulated in a quantitative manner and integrated to describe various aspects of plant behavior, including growth and yield. Consideration is given to characterization of the plant environment, energy balance, gas exchange, water relations, photosynthesis, respiration, translocation, nutrient supply, and the timing of developmental events.]

652 Botanical Latin Spring. 1 credit. Prerequisite: written permission of instructor. S-U grades optional. Offered alternate years.
Lec and disc to be arranged. W. J. Dress.
Basic grammar and vocabulary and exercises in writing and reading the Latin of plant taxonomy, as well as applications to botanical nomenclature.

654 Plant Nomenclature Spring. 1 credit. Prerequisite: written permission of instructor. Recommended: concurrent enrollment in Biological Sciences 652. S-U grades optional. Offered alternate years.
Lec and disc to be arranged. W. J. Dress.
An analysis of the International Code of Botanical Nomenclature and its application to various plant groups.

656 Topics in Paleobotany Spring. 1 credit. Prerequisite: Biological Sciences 448 or equivalent background in evolution, or written permission of instructor.
Lab and disc to be arranged. K. J. Niklas.
A series of selected topics designated to provide a background in plant evolution, paleobotanical literature, and evolutionary theory. Among the topics discussed are the origin of a terrestrial flora, the evolution of the seed plants, and the origin and adaptive radiation of the angiosperms.

657 Literature of Taxonomic Botany Fall. 1 credit. Prerequisite: written permission of instructor. S-U grades optional. Offered alternate years.
Lec and disc, R 10:10. J. W. Ingram.
A survey of the basic reference works in taxonomy from the pre-Linnaean literature drawn on by Linnaeus to contemporary publications, with comments on the peculiarities of the books (when appropriate), publication dates, typographic devices, and intricacies of bibliographic citation.

740 Plant Biology Seminar Fall and spring. Noncredit (no official registration). Required of graduate students doing work in plant physiology.
Sem, F 11:15. Staff.
Lectures on current research in plant biology, presented by visitors and staff.

749 Graduate Research in Botany Fall or spring. Variable credit. May be repeated for credit. S-U grades optional.
Hours to be arranged. Staff.
Similar to Biological Sciences 499 but intended for graduate students who are working with faculty members on an individual basis.

840 Current Topics in Plant Physiology Fall or spring. 2 credits. May be repeated for credit. S-U grades only.
Sem to be arranged. Staff.
Seminar reports by graduate students on current literature in experimental plant physiology or related areas.

Related Courses in Other Departments

Advanced Mycology (Plant Pathology 709)

Current Topics in Mycology (Plant Pathology 649)

Field Phycology (Biological Sciences 441)

Introductory Mycology (Plant Pathology 309)

Plant Ecology (Biological Sciences 463, 465)

Plant Ecology Seminar (Biological Sciences 669)

Taxonomy of Fungi (Plant Pathology 729)

Teaching Experience (Biological Sciences 498)

Undergraduate Research in Biology (Biological Sciences 499)

Ecology, Systematics, and Evolution

260 Introductory Ecology Fall or spring. 3 credits. Prerequisite: one year of introductory biology or written permission of instructor. May not be taken for credit after Biological Sciences 360.
Lecs, T R 11:15; disc, T or R 1:25, 2:30, or 3:35. Fall: S. J. Risch; spring: P. F. Brussard.
An introduction to biological phenomena that occur at the population, community, and ecosystem levels of organization. The relevance of ecological principles to current environmental problems is examined.

274 The Vertebrates Spring. 5 credits. Primarily for sophomores; this course is a prerequisite for many advanced courses in vertebrate biology, anatomy, and physiology. Each lab limited to 21 students. Prerequisite: one year of introductory biology for majors. Fee, $10.
Lecs, T R 10:10; labs, M W 1:25–5, M W 7–10 p.m., or T R 1:25–5. Evening prelim: Mar. 23. Staff.
An introduction to the evolution, classification, comparative anatomy, life history, and behavior of vertebrate animals. Laboratory dissection and demonstration are concerned with structure, classification, systematics, biology of species, and studies of selected aspects of vertebrate life.

360 General Ecology Fall or spring. 3 credits. For students concentrating in ecology or a related subject. Not open to freshmen in fall semester. Prerequisite: one year of introductory biology for majors. May not be taken for credit after Biological Sciences 260.
Lecs, T R 9:05; disc, W or R 1:25, 2:30, or 3:35. Fall: P. L. Marks, P. P. Feeny; spring: R. B. Root, B. F. Chabot.
Principles concerning the interactions between organisms and their environment; influence of competition, predation, and other factors on population size and dispersion; analysis of population structure and growth; processes of speciation; interspecific competition and the niche concept; succession and community concepts; influence of climate and past events on the diversity and stability of communities in different regions of the world; and role of energy flow and biogeochemical cycling in determining the structure and productivity of ecosystems. Modern evolutionary theory is stressed throughout and attention is given to conflicting ecological hypotheses.

371 Human Paleontology Fall. 4 credits. Prerequisite: one year of introductory biology or permission of instructor.
Lecs, M W F 2:30; lab, 1 hour each week, to be arranged; occasional field trips. K. A. R. Kennedy.
A broad survey of the fossil evidence for human evolution with special attention to skeletal and dental anatomy, geological contexts, paleoecology, dating methods, archaeological associations, and current theories of primate phylogeny.

455 Insect Ecology, Lectures (also Entomology 455) Fall. 2 credits. Prerequisites: Biological Sciences 360 and Entomology 212, or their equivalents. Recommended: concurrent enrollment in Biological Sciences 457. Offered alternate years.
Lecs, W F 11:15. R. B. Root.
Ecological and evolutionary principles are integrated by thorough examination of outstanding investigations. Topics discussed include the factors responsible for the great diversity of insects, adaptive syndromes associated with climate, natural history of arthropod guilds, impact of insects on terrestrial vegetation, population regulation, and the contrast between natural and managed ecosystems.

457 Insect Ecology, Laboratory (also Entomology 457) Fall. 2 credits. Limited to 16 students. Prerequisite: concurrent enrollment in Biological Sciences 455. Offered alternate years.
Lab, W 1:25–4:25; plus F or S field trips to be arranged during the field season. R. B. Root.
Field exercises focus on insect natural history and methods of sampling populations. Laboratories devoted to rearing insects, estimating life-table parameters, and analyzing communities.

461 Oceanography Fall. 3 credits. Prerequisites: college physics and either Biological Sciences 260 or 360; or written permission of instructor. S-U grades optional.
Lecs, T R 10:10; additional lec, R 12:20, alternating with disc, T or R 1:25. J. P. Barlow.
A general introduction to the oceans, with emphasis on physical and chemical processes that interact with marine communities. Discussions use case studies from current literature to illustrate application to problems in biological oceanography. Field techniques and analytical methods are demonstrated.

462 Limnology, Lectures Spring. 3 credits. Prerequisite: Biological Sciences 260 or 360, or written permission of instructor.
Lecs, M W F 11:15. G. E. Likens.
A study of the interaction of biological communities and their aquatic environment. The physical, chemical, and biological dynamics of freshwater ecosystems.

463 Plant Ecology, Lectures Fall. 3 credits. Prerequisites: two advanced-level courses in biology, including Biological Sciences 360, or written permission of instructor. Recommended: some taxonomic familiarity with vascular plants and concurrent enrollment in Biological Sciences 465.
Lecs, M W F 11:15. P. L. Marks.
Principles of plant-environment interactions in relation to the evolution, distribution, structure, and functioning of plants and plant communities.

464 Limnology, Laboratory Spring. 2 credits. Prerequisite: concurrent or previous enrollment in Biological Sciences 462.
Lab, T W R or F 1:25–4:25; 1 all-day, overnight field trip. G. E. Likens, W. R. Schaffner.
Field trips and laboratories devoted to studies of aquatic ecosystems.

465 Plant Ecology, Laboratory Fall. 1 credit. Prerequisite: concurrent enrollment in Biological Sciences 463 or equivalent background in plant ecology.
Lab, F 12:05–5. P. L. Marks.
Laboratory and field exercises in plant ecology. Field studies of plant communities and techniques for the analysis of community data are emphasized.

468 Systems Ecology Spring. 4 credits. Prerequisites: Biological Sciences 360 and calculus. Recommended: Computer Science 102. S-U grades optional.
Lecs, M W F 10:10; disc, T or R 2:30–4:05. C. A. S. Hall.
An introduction to the quantitative study of populations, communities, and ecosystems. Emphasis on the development and validation of computer models based on component interactions and entire systems. Topics covered include relevant

ecological principles, system diagramming, rudimentary mathematical techniques, simulation modeling, and the use of analog and digital computers. Format includes student presentations and guest lectures describing individual case histories in which a variety of methods were used for ecological analysis, simulation, or prediction. Each student is required to develop an original computer model.

[470 Undergraduate Ecology Seminar Fall or spring. 1 or 2 credits. May be repeated for credit. From time to time different seminars are offered. Not offered 1981–82.]

471 Mammalogy Fall. 4 credits. Recommended: Biological Sciences 274. S-U grades optional, with permission of instructor. Offered alternate years. Fee, $15.

Lecs, M W F 9:05; lab, M or T 1:25–4:25; 1 weekend field trip required. P. J. Parker.

Lectures on the evolution, classification, distribution, and adaptations of mammals. Laboratory and fieldwork on systematics, ecology, and natural history of mammals of the world, with primary emphasis on the North American fauna. Systematics laboratories held in the museum at Research Park.

472 Herpetology Fall. 4 credits. Recommended: Biological Sciences 274. S-U grades optional, with permission of instructor. Offered alternate years. Fee, $5.

Lecs and labs, T R 12:20–4:25; occasional field trips and special projects. F. H. Pough.

Lectures cover various aspects of the biology of amphibians and reptiles, including evolution, zoogeography, ecology, behavior, and physiology. Laboratory includes systematics, functional morphology, and behavior.

474 Laboratory and Field Methods in Biological Anthropology Spring. 4 credits. Prerequisite: one year of introductory biology or permission of instructor.

Labs, T R 10:10–12:05; additional hours to be arranged. Independent research project required. K. A. R. Kennedy.

Practical exercises and demonstrations of modern approaches to the methodology of physical anthropology. Emphasis upon comparative primate anatomy, the human paleontological record, description of skeletal and living subjects, paleopathology, skeletal maturation, and relevant field techniques for the archaeologist.

475 Ornithology Fall. 4 credits. Recommended: Biological Sciences 274. S-U grades optional, with permission of instructor. Offered fall 1981, fall 1982, and alternate fall terms thereafter.

Lecs and labs, T R 12:20–4:25; occasional field trips and special projects. T. J. Cade.

Lectures cover various aspects of the biology of birds, including anatomy, physiology, classification, evolution, migration and orientation, behavior, ecology, and distribution, and are fully integrated with laboratory studies. Laboratory includes studies of external and internal morphology, pterylosis, molts and plumages, specimen identification of birds of New York, and families of birds of the world. Several demonstration periods emphasize hybridization, evolution, adaptive radiation, mimicry, and geographic variation.

[476 Biology of Fishes Fall. 4 credits. Prerequisite: Biological Sciences 274, or equivalent experience in vertebrate zoology with written permission of instructor. S-U grades optional, with permission of instructor. Offered alternate years. Not offered 1981–82.

Lecs, M W F 9:05; lab to be arranged. E. B. Brothers.

An introduction to the study of fishes: their structure, classification, evolution, distribution, ecology, physiology, and behavior.]

477 Organic Evolution Fall. 4 credits. Prerequisite: Biological Sciences 281 or permission of instructor. Recommended: Biological Sciences 260 or 360.

Lecs, T R 11:15; lec or disc, R 12:20; optional sessions to be arranged. P. F. Brussard.

Lectures and class discussions on organic evolution, including the origin of life, genetic mechanisms, the properties of populations, the ways in which adaptation and speciation occur, and the resultant major patterns of organic diversity.

[478 Biology of Fishes, Laboratory Fall. 1 credit. Limited to 15 students. Prerequisite: concurrent enrollment in Biological Sciences 476. Offered alternate years. Not offered 1981–82.

Lab, M 1:25–4:25; plus irregular hours as required for experiments and some required field trips. E. B. Brothers.

Laboratory and fieldwork on structure, identification, ecology, physiology, and behavior of fishes, with emphasis on local species.]

479 Physical Anthropology: History and Theory Fall. 2 credits. Prerequisite: one year of introductory biology or permission of instructor.

Sem, W 7:30–9:30 p.m. K. A. R. Kennedy.

The historical background of present-day concepts of man's evolutionary variations and adaptations in space and time is surveyed. The formation of biological anthropology as an area of scientific inquiry within the social sciences is reviewed.

660 Field Studies in Ecology and Systematics Fall or spring. 2 credits. Prerequisites: Biological Sciences 260 or 360, a taxon-oriented course, and permission of instructor. Estimated cost of room and board (exclusive of transportation), to be announced.

Lecs and labs to be arranged. Staff.

This course provides students an opportunity to learn techniques and a new biota by participating in an intensive series of field exercises. An extended field trip is scheduled either during intersession or spring break. The region visited, trip objectives, and other details are announced by the instructor in charge in the division's catalog supplement issued at the beginning of the semester. Meetings on campus are devoted to orientation and reports on completed projects.

[662 Mathematical Ecology (also Statistics and Biometry 662) Spring. 3 credits. Prerequisites: one year of calculus and a course in statistics. Recommended: a general ecology course. S-U grades optional, with permission of instructor. Offered alternate years. Not offered 1981–82.

Lecs, M W F 12:20. S. A. Levin.

Mathematical and statistical analysis of populations and communities: theory and methods. Spatial and temporal pattern analysis. Deterministic and stochastic models of population dynamics. Model formulation, parameter estimation, simulation, and analytical techniques.]

[664 Seminar in Coevolution between Insects and Plants (also Entomology 664) Spring. 2 credits. Intended for seniors and graduate students. Limited to 15 students. Prerequisites: courses in entomology, ecology, evolution, and organic chemistry, and written permission of instructor. S-U grades optional. Offered alternate years. Not offered 1981–82.

Sem, 1 evening each week, to be arranged. P. P. Feeny.

Presentations and discussions by students on the evolution of patterns of interaction between plants and insects, emphasizing critical evaluation of concepts and evidence.]

665 Limnology Seminar Fall. 1 credit. May be repeated for credit. Primarily for graduate students; written permission of instructor required for undergraduates. S-U grades optional.

Sem to be arranged. G. E. Likens.

A seminar course on advanced limnological topics.

666 Marine Ecology Spring. 3 credits. Prerequisite: Biological Sciences 260 or 360, or written permission of instructor. Recommended: Biological Sciences 461. S-U grades optional.

Lecs, M W F 9:05. J. P. Barlow.

An introduction to biological oceanography, including adaptation of organisms to marine environments, organization of pelagic and benthic communities, and dynamics of marine ecosystems, with some special consideration of current research in coastal and estuarine regions.

[667 Topics in Theoretical Ecology Fall. 3 credits. Primarily for graduate students; permission of instructor required for undergraduates. Prerequisite: one year of calculus. Recommended: Biological Sciences 662. S-U grades optional. Offered alternate years. Not offered 1981–82.

Lecs, 3 hours each week, to be arranged. S. A. Levin.

Current and classical theoretical issues in ecology and evolutionary biology. Biological issues are emphasized, although mathematical models are utilized throughout as tools to address those issues. Lectures cover both standard material and current journal articles.]

[668 Physiological Ecology of Phytoplankton Spring. 2 credits. Prerequisites: Biological Sciences 360 and Agronomy 410; or permission of instructor. S-U grades optional. Offered alternate years. Not offered 1981–82.

Lecs and discs, 4 hours alternate weeks, to be arranged. G-Y. Rhee.

Ecological observations in nature interpreted with respect to the findings of algal culture studies. Emphasis is placed upon photosynthesis, nutrient limitation, temperature, irradiance, diel periodicity, and other physiological and environmental variables. The theory and use of various culture methods are also emphasized.]

[669 Plant Ecology Seminar Fall. 1 credit. May be repeated for credit. Suggested for students majoring or minoring in plant ecology. S-U grades optional. Not offered 1981–82.

Sem to be arranged. B. F. Chabot, P. L. Marks.

Includes review of current literature, student research, and selected topics of interest to participants.]

670 Graduate Seminar in Vertebrate Biology Fall or spring. 1 credit. May be repeated for credit. Primarily for graduate students; written permission of instructor required for undergraduates.

Sem to be arranged. Vertebrate biology staff.

Seminar presentations and discussions by students on areas of current research in vertebrate biology. Topics vary from semester to semester.

[679 Ichthyology Fall. 5 credits. Enrollment limited. Prerequisites: Biological Sciences 476 and 478; or written permission of instructor. Offered alternate years. Not offered 1981–82.

Lecs, M W 10:10; labs, W F 1:25–5; plus irregular hours as required for experiments and some required field trips. Independent research project or term paper required. E. B. Brothers.

Lectures on advanced topics in fish biology, including systematics, ecology, behavior, life history, and literature. Laboratory studies of the orders, major families, and principal genera and of systematic procedures. Field studies of the ecology and life history of local species.]

760 Special Topics in Evolution and Ecology Fall or spring. 1–3 credits. May be repeated for credit. Enrollment limited. S-U grades optional, with permission of instructor.

Hours to be arranged. Staff.

Independent or group intensive study of special topics of current interest. Content varies and is arranged between student and staff member.

761 Seminar in Population and Community Ecology Fall. 1 credit. May be repeated for credit. Prerequisite: permission of instructor. S-U grades optional.
Sem, T 4:25. Staff.
A seminar course on selected topics in population and community ecology. Topics vary from year to year.

765 Autecology Fall. 3 or 4 credits (4 credits with term paper). Offered alternate years.
Lecs M W F 9:05. B. F. Chabot and staff.
Comparison of the responses and adaptations of organisms to environment in selected ecosystems. Emphasis on similarities and differences in molecular and organismal mechanisms by which plants and animals cope with their environments.

766 Population Ecology Spring. 3 or 4 credits (4 credits with term paper). Prerequisite: graduate standing with some background in calculus, statistics, ecology, and evolutionary theory; or written permission of instructor. Offered alternate years.
Lecs and discs, M W F 9:05. P. F. Brussard and staff.
Critical examination of the properties and dynamics of populations. Emphasis on theories of population structure, dynamics, and regulation. Discussion of experimental approaches to analyses of natural populations.

[767 Community Ecology Fall. 3 or 4 credits (4 credits with term paper). Prerequisite: Biological Sciences 360 or equivalent, or written permission of instructor. Offered alternate years. Not offered 1981–82.
Lecs, T R 10:10–12:05. Staff.
The structure and dynamics of natural communities; patterning and sampling problems; species diversity; niches and gradient relations; and ordination, classification, succession, climax, and disturbance. Comparative aspects of terrestrial, marine, and freshwater communities are stressed.]

[768 Ecosystems Spring. 3 or 4 credits (4 credits with term paper). Prerequisite: Biological Sciences 360 or equivalent, or written permission of instructor. Offered alternate years. Not offered 1981–82.
Lecs, T R 10:10–12:05. G. E. Likens and staff.
Analysis of ecosystems in terms of energy flow, biogeochemistry, and model systems. Emphasis on the functional properties of ecosystems, from simple systems to the biosphere as a whole.]

Population Biology of Health and Disease (Veterinary Medicine 330) Spring. 3 or 4 credits (4 credits with either lab exercises or library research).
Lecs, T R 11:15; disc and demonstration, T 2–3:30. J. H. Whitlock and staff.
An integrative study of the problems of health and disease in populations of humans, plants, and animals. Examples are drawn from the whole symbiotic spectrum. Parasitoses that result in disease are demonstrated to have comparable structures and functions. These structures and functions are examined as adaptive phenomena from ecological, genetic, sociological, and economic points of view. In the demonstrations, specific diseases or symbioses are presented for discussion either through the medium of motion pictures or by specialists (such as epidemiologists, virologists, plant nematologists, and insect pathologists) from the Cornell staff.

Related Courses in Other Departments

Advanced Insect Taxonomy (Entomology 631, 632, 633, 634)

Advanced Soil Microbiology (Agronomy 606)

Advanced Work in Animal Parasitology (Veterinary Medicine 737)

Biology of Plant Species (Biological Sciences 442)

Ecological Animal Physiology (Biological Sciences 315, 317)

Ecology and Systematics of Freshwater Invertebrates (Entomology 471)

Insect Biology (Entomology 212)

Insect Pathology (Entomology 453)

Introductory Insect Taxonomy (Entomology 331)

Invertebrate Zoology (Biological Sciences 212)

Marine Sciences (Biological Sciences 363–370, 467, 473)

Microbial Ecology (Agronomy 410 and Microbiology 424)

Parasitic Helminthology (Veterinary Medicine 440)

Phycology (Biological Sciences 348)

Plant Geography (Biological Sciences 440)

Soil Microbiology (Agronomy 406)

Taxonomy of Vascular Plants (Biological Sciences 343)

Teaching Experience (Biological Sciences 498)

Undergraduate Research in Biology (Biological Sciences 499)

Vertebrate Social Behavior (Biological Sciences 427)

Genetics and Development

281 Genetics Fall or spring. 5 credits. Not open to freshmen in fall semester. Prerequisite: one year of introductory biology or equivalent. Students who have taken Biological Sciences 282 may register only with written permission of instructor. No admittance after first week of classes.
Lecs, T R 10:10–12:05; lab, M T W or R 2:30–4:25; additional hours to be arranged. Lab sections may also be scheduled T or R 8–9:55, W or F 10:10–12:05, F 2:30–4:25, or S 10:10–12:05, if enrollment requires it. Students do not choose lab sections during course enrollment; lab assignments are made during first day of classes. Fall: R. J. MacIntyre; spring: T. D. Fox; lab: P. J. Bruns.
A general study of the fundamental principles of genetics in eucaryotes and procaryotes. Discussions of gene transmission, gene action and interaction, gene linkage and recombination, gene structure, gene and chromosome mutations, genetic aspects of differentiation, genes in populations, breeding systems, and extrachromosomal inheritance. In the laboratory students perform experiments with microorganisms and conduct an independent study of inheritance in *Drosophila*.

282 Human Genetics Spring. 3 credits. Each disc section limited to 25 students. Prerequisite: one year of introductory biology or equivalent. Students who have taken Biological Sciences 281 may register only with written permission of instructor.
Lecs, M W 10:10; disc, R or F 10:10 or 11:15 (1 disc section R 10:10, 2 sections R 11:15, 4 sections F 10:10, and 1 section F 11:15). A. M. Srb.
An introduction to biological heredity through consideration of human genetics. Advances in the science of genetics are having a profound effect on our understanding of ourselves and on our potential for influencing our present and future well-being. The course is intended primarily to contribute to the student's general education in these matters. Although certain aspects of genetics are considered with some rigor, the course is not designed to serve as a prerequisite to advanced courses in genetics.

385 Developmental Biology Fall. 3 credits. Prerequisite: Biological Sciences 281.
Lecs, M W F 11:15. A. W. Blackler.
Morphogenetic, cellular, and genetic aspects of the developmental biology of animals.

[389 Embryology Fall; also offered during the 6-week summer session in odd-numbered years. 4 credits. Prerequisite: one year of introductory biology. Offered alternate years. Not offered 1981–82.
Lecs, M W 11:15; labs, M W 2–4:25. A. W. Blackler.
A course in the embryonic development of animals, with emphasis directed to the vertebrate groups and to the comparative aspects of morphogenesis and function. Invertebrate material is used on occasion to illustrate embryological principles. The laboratory has a strong morphogenetic theme, and stresses the comparative aspects of developmental anatomy.]

[480 Seminar in Developmental Biology Spring, weeks 1–7. 1 credit; may be repeated for credit. Limited to upperclass students. S-U grades only. Not offered 1981–82. Sem to be arranged. Staff (coordinator: A. W. Blackler).]

[481 Population Genetics Fall. 3 credits. Prerequisite: Biological Sciences 281 or equivalent. S-U grades optional. Not offered 1981–82.
Lecs, M W 10:10. Staff.
A study of factors that influence the genetic structure of Mendelian populations and that are involved in race formation and speciation. Four quizzes and an optional term paper determine the final grade.]

483 Molecular Aspects of Development Spring. 3 credits. Prerequisite: Biological Sciences 330 or 331. Offered alternate years.
Lecs, M W F 11:15. Staff.
An examination of the molecular biology of developing systems. Emphasis on understanding the mechanisms involved in gene expression in developing systems, both at the transcription and translation levels. Specific topics include regulation of RNA synthesis and utilization, nucleo-cytoplasmic interactions, and induction of cell-specific protein synthesis. Examples are discussed from both higher and lower eucaryotic systems.

484 Molecular Evolution Spring. 3 credits. Prerequisites: Biological Sciences 281 and organic chemistry. Offered alternate years.
Lecs, T R 11:15. R. J. MacIntyre.
An analysis of evolutionary changes in proteins and nucleic acids, and gene-enzyme variability in natural populations. The role of natural selection in effecting these changes and maintaining genetic variation at the molecular level is critically examined. Theories on the evolution of the genetic code and the construction of phylogenetic trees from biochemical data are discussed.

485 Microbial Genetics, Lectures Fall. 2 credits. Limited to upperclass and graduate students. Prerequisites: Biological Sciences 281 and Microbiology 290; or written permission of instructor. S-U grades optional.
Lec, W 7:30–9:25 p.m. S. A. Zahler.
Genetics of bacteria and their viruses, with emphasis on the mechanisms of genetic phenomena.

486 Immunogenetics (also Animal Science 486) Spring. 4 credits. Enrollment limited. Prerequisites: Biological Sciences 281 or Animal Science 221, and a course in immunology or permission of instructor.
Lecs, M W F 10:10; disc, W or R 12:20. R. R. Dietert.
The genetic control of a variety of cellular antigens and their use in understanding biological and immunological functions. The genetics of antibody diversity, antigen recognition, immune response, transplantation, and disease resistance are discussed.

487 Microbial Genetics, Laboratory Fall. 3 credits. Primarily for upperclass students. Limited to 20 students. Prerequisites: concurrent or previous enrollment in Biological Sciences 485, Microbiology 291 or equivalent, and written permission of instructor.

Lab, T 1:25–4:25; additional hours to be arranged. S. A. Zahler.

Problem solving in bacterial genetics.

780 Current Topics in Genetics Fall or spring. 2 credits. May be repeated for credit. Primarily for graduate students, with preference given to majors in the Field of Genetics; written permission of instructor required for undergraduates. Limited to 20 students. No auditors. S-U grades optional, with permission of instructor.

Sem to be arranged. Staff.

A seminar course with critical presentation and discussion by students of original research papers in a particular area of current interest. Content of the course and staff direction varies from term to term and will be announced a semester in advance.

Related Courses in Other Departments

Animal Cytogenetics (Animal Science 419)

Behavioral Neurogenetics (Biological Sciences 624)

Current Topics in Biochemistry (Biological Sciences 732–738)

Cytogenetics (Biological Sciences 446)

Cytology (Biological Sciences 347)

Invertebrate Embryology (Biological Sciences 482)

Organic Evolution (Biological Sciences 477)

Physiological Genetics of Crop Plants (Plant Breeding 605)

Plant Growth and Development (Biological Sciences 644)

Teaching Experience (Biological Sciences 498)

Undergraduate Research in Biology (Biological Sciences 499)

Neurobiology and Behavior

321 Neurobiology and Behavior Fall. 3 credits. Prerequisite: one year of introductory biology. S-U grades optional, with permission of instructor.

Lecs, M W F 12:20. Evening prelims: Oct. 13 and Nov. 17. S. T. Emlen, R. R. Capranica, and staff.

A general introduction to the field of neurobiology and behavior. Topics include evolution of behavior, cueing of behavior, animal orientation, social and nonsocial behavior, neuroanatomy, neurophysiology, neurochemistry, neural networks, and memory.

322 Hormones and Behavior (also Psychology 322) Spring. 3 or 4 credits (4 credits with discussion and term paper). Primarily for upperclass students; permission of instructor required for sophomores. Prerequisites: one year of introductory biology, and Biological Sciences 321 or a course in psychology. S-U grades optional.

Lecs, T R 10:10–11:30; disc to be arranged. E. Adkins Regan, R. E. Johnston.

The relationship between endocrine and neuroendocrine systems and the behavior of animals, including humans. Major emphasis is on sexual, parental, and aggressive behavior.

324 Biopsychology Laboratory (also Psychology 324) Spring. 3 credits. Limited to 25 upperclass students. Prerequisites: laboratory experience in biology or psychology, Biological Sciences 321 or Psychology 123, and permission of instructor. S-U grades optional.

Labs, T R 1:25–4:25. Staff.

Experiments designed to provide research experience in animal behavior (including learning) and its neural and hormonal mechanisms. A variety of techniques, species, and behavior patterns are included.

[395 Vision (also Engineering A&EP 611) Fall. 3 credits. Prerequisites: Chemistry 104 or 208; Mathematics 106, 111, or 113; and either Physics 102 or 208; or permission of instructor. Offered alternate years. Not offered 1981–82.

Lecs, M 1:25 and T R 10:10. R. K. Clayton.

A study of the mechanism of seeing that includes biological, physical, and chemical approaches to the subject.]

[396 Introduction to Sensory Systems (also Psychology 396) Spring. 3 credits. No auditors. Prerequisites: an introductory course in biology or biopsychology, and a second course in neurobiology and behavior or perception or cognition or biopsychology; students are expected to have elementary knowledge of perception, neurophysiology, behavior, and chemistry. S-U grades optional for graduate students only. Not offered 1981–82; next offered spring 1983 and each spring term thereafter.

Lecs, T R 9:05; disc to be arranged. B. P. Halpern.

Both those characteristics of sensory systems that are common across living organisms and those sensory properties that represent adaptations of animals to particular habitats or environments are studied. The principles and limitations of major methods used to examine sensory systems are considered. Behavioral (including psychophysical, biophysical, and neurophysiological) and anatomical methods are usually included. The course is taught using the Socratic method, in which the instructor asks questions of the students.]

420 Seminar in Neurobiology and Behavior Fall or spring. Variable credit. May be repeated for credit. Primarily for undergraduates. S-U grades optional.

Sem to be arranged. Organizational meetings first W of each semester at 8 p.m. in Caldwell 100. Staff.

In most semesters, at least two seminars on different topics are offered. Topics and instructors are listed in the division's catalog supplement issued at the beginning of the semester.

421 Comparative Vertebrate Ethology Fall; also offered during the 3-week summer session. 3 credits. Prerequisites: one year of introductory biology for majors, Biological Sciences 321, and permission of instructor. S-U grades optional.

Lecs, T R 9:05; lab to be arranged. Independent research project required. W. C. Dilger.

A survey of the methods and principles of vertebrate ethology, including such topics as aggression, fear, sex, feeding, and other normal activities. Emphasis is placed on the causation, function, biological significance, and evolution of species-typical behavior. The laboratories are designed to give firsthand knowledge of the material covered in lectures. During the summer, field trips and field projects are substituted for many of the laboratories.

[423 Animal Communication Fall. 4 credits. Limited to 32 students. Prerequisites: Biological Sciences 321 and either Physics 102 or 208. Offered alternate years. Not offered 1981–82.

Lecs, T R 10:10; lab, T or R 1:25–4:25; other meetings to be arranged. R. R. Capranica, R. R. Hoy.

The functional aspects of biological signals, their physical properties, and the physiological mechanisms underlying their generation and reception. Lectures examine in detail selected biological communication problems from each of the known sensory modalities. Discussion covers signal analysis, transmission properties, and the limitations of each type of communication. Laboratories include behavioral observations under both field and captive conditions, and individual experience with the techniques of signal recording and analysis.]

424 Animal Social Behavior Spring. 3 credits. May be repeated for credit with permission of instructor. Prerequisite: Biological Sciences 321. S-U grades optional.

Lecs, T R 10:10–11:30. G. Hausfater.

This course examines animal social behavior and social organization in a phylogenetic perspective. A different taxonomic group serves as the focus of the course each year.

425 (628) Field Studies of Animal Behavior Fall. 4 credits. Limited to 12 students. Prerequisites: Biological Sciences 321 and written permission of instructor. Recommended: concurrent or previous enrollment in Biological Sciences 421 or 427. S-U grades optional. Fee, $15.

Lec, T 9:05; lab and disc, R 1:25–4:25; Saturday field trips during the field season; 2 weekend field trips and occasional evening meetings. Enrolled students must participate in all aspects of the course; no partial credit given. P. W. Sherman.

A course for juniors, seniors, and first-year graduate students interested in field research on animal behavior. Lecture-discussion areas include design of field experiments, hypothesis testing, data analysis, and current topics in evolutionary ecology and behavior. Laboratory field sessions acquaint students with observation techniques; research methods; and the behavioral biology of plants, insects, fishes, amphibians, birds, and mammals of upstate New York.

427 Vertebrate Social Behavior Spring. 3 credits. Prerequisites: Biological Sciences 321, and 260 or 360. S-U grades optional, with permission of instructor. Offered alternate years. Offered spring 1982; next offered fall 1983 and alternate fall terms thereafter.

Lecs, M W F 10:10; disc to be arranged. S. T. Emlen.

The study of the adaptive bases of social behavior is examined. The first half of the course deals with ecological sociobiology: the effects of ecological constraints of resource dispersion and predation pressures upon the structure of animal societies; the adaptiveness of territoriality and coloniality; the evolution of cooperative and communal social systems; and the functioning of monogamous, polygamous, and promiscuous mating systems. The second half of the course emphasizes genetic sociobiology: the predictions from individual and kin-selection theory for various types of social interactions, e.g., female choice during mate selection; the role of the male in parental care; parent-offspring conflict; behavioral nepotism; and the evolution of phenotypic altruism. Finally, the course examines the impact of the emerging field of sociobiology upon its sister biological and social sciences.

491 Principles of Neurobiology, Laboratory (also Psychology 491) Fall. 4 credits. Limited to 24 students. Prerequisite: Biological Sciences 396 or 496, or written permission of instructor.

Labs, M W or T R 12:20–4:25; additional hours to be arranged. B. R. Land and staff.

Laboratory practice with neurobiological preparations and experiments, designed to teach the techniques, experimental designs, and research strategies used to study biophysical and biochemical properties of excitable membranes, sensory receptors, and the central nervous system transformation of afferent activity, as well as the characteristic composition and metabolism of neural tissue. Theoretical content at the level of Aidley's *The Physiology of Excitable Cells*.

[494 Neuropharmacology Spring. 3 credits. Prerequisites: Biological Sciences 321 and either 330 or 331; or written permission of instructor. Not offered 1981–82.

Lecs, M W F 8. Staff.

Deals with drugs that affect the nervous system, both central and peripheral. Emphasis is on mechanisms of drug action whereby basic biochemical processes and neurophysiological and behavioral phenomena are bridged. Stimulants, anesthetics, hallucinogens, and neurotoxins are discussed, as well as drug addiction, psychopharmacology, endocrine pharmacology, and the biochemical basis of the therapeutic uses of drugs in diseases of the nervous system.]

496 Cellular Neurobiology Spring. 4 credits. Prerequisite: Biological Sciences 321.

Lecs, M W F 10:10; disc to be arranged.

R. B. Campenot, R. M. Harris-Warrick, R. R. Hoy.

A one-semester, intensive undergraduate course in neurobiology. The course provides in-depth, current treatment of the basic principles of cellular, chemical, pharmacological, molecular, anatomical, and integrative aspects of neurobiology.

[497 Neurochemistry Fall. 3 credits. Limited to 30 students. Prerequisites: Biological Sciences 496 and either 330 or 331, or permission of instructor. S-U grades optional. Offered alternate years. Not offered 1981–82.

Lecs and discs, M W F 9:05. R. M. Harris-Warrick.

This course focuses primarily on synaptic neurochemistry. The presynaptic regulation and postsynaptic mechanism of action of the major classes of neurotransmitters are discussed, as well as selected neuromodulators and hormones. The relevance of basic mechanisms to normal brain function and neurological disorders are described. Readings are primarily from journal articles.]

623 Chemical Communication (also Chemistry 622) Fall. 3 credits. Primarily for research-oriented students. Limited to 30 senior and graduate students. Prerequisites: one year of introductory biology for majors or equivalent, course work in biochemistry, and Chemistry 358 or equivalent. Offered alternate years.

Lecs, M W F 1:25. T. Eisner, J. Meinwald, W. L. Roelofs, and guest speakers.

The production, transmission, and reception of chemical signals in communicative interactions of animals, plants, and microorganisms. Studies of insects are emphasized. Specific topics are treated, with varying emphasis on chemical, biochemical, neurobiological, ecological, and evolutionary principles.

[624 Behavioral Neurogenetics Spring. 3 credits. Primarily for research-oriented students. Prerequisites: Biological Sciences 321 and 281. Recommended: course work in developmental biology. S-U grades optional. Offered alternate years. Not offered 1981–82.

Lecs, T R 9:05; disc and demonstration to be arranged. R. R. Hoy.

The study of the neurogenetic basis of behavior in animals, using "simple" behaviors that can be analyzed genetically and neurobiologically. Both vertebrate and invertebrate animals are discussed, although emphasis is on the invertebrates. Lectures and assigned readings draw heavily from journal articles.]

627 Quantitative Approaches to Animal Behavior Spring. 3 credits. Primarily for graduate students; written permission of instructor required for undergraduates. Enrollment limited. Prerequisite: Biological Sciences 321 or equivalent. S-U grades optional, with permission of instructor. Offered alternate years.

Lecs and discs, T R 10:10–11:30. G. Hausfater.

This course emphasizes a quantitative approach to research on animal behavior. Lectures, discussions, and readings focus on the formulation of precise, testable hypotheses for behavior research, especially mathematical models, and on the use of systematic sampling techniques in observational research. Basic probability distributions are introduced and used in the analysis of behavior sequences and interaction patterns. Stochastic models of behavior are also discussed.

[691 Developmental Neurobiology Fall. 2 credits. Prerequisite: Biological Sciences 496 or permission of instructor. S-U grades optional, with permission of instructor. Offered alternate years. Not offered 1981–82.

Lecs and discs, 2 hours each week, to be arranged. R. B. Campenot.

The embryologic development of the nervous system is considered in the light of both historical and current research. Emphasis is on cellular issues, i.e., How do nerve cells differentiate both morphologically and biochemically, and how do they interact to produce a properly wired nervous system?]

695 Physiological Optics Fall. 3 credits. Limited to 24 students. Recommended: courses in elementary biology or psychology, and physics, and courses appropriate to particular track (see below). Offered alternate years.

Lecs, T R 9:05; lab, R 1:25–4:25. H. C. Howland.

The course is primarily for upperclass students who intend to pursue research or conduct clinical work in vision. Topics include geometrical optics, clinical refraction, measurement of MTF and contrast sensitivity, and the vegetative physiology of the eye relevant to optical quality of the optical image.

Laboratory work is divided into three tracks: (1) *Clinical track* for students intending to work in optometry or medicine; (2) *Psychophysical track* for students intending to conduct research in human or animal vision; and (3) *Engineering track* for students intending to use or design optical devices for which the human eye is a component in the system.

Grades are based on the student's accomplishments within the chosen track, in view of the background brought to it.

[696 Neuroelectric Systems (also Electrical Engineering 622) Spring. 3 or 4 credits (4 credits with lab). Prerequisite: either Biological Sciences 423 or 496 or Electrical Engineering 301 or 621; written permission of instructor required for lab. Offered alternate years. Not offered 1981–82.

Lecs, M W 9:05; disc and demonstration to be arranged; lab to be arranged. R. R. Capranica, M. Kim.

Application of microprocessors for neuroelectric data acquisition and systems analysis. Lectures cover electrical activity of single nerve cells, electrodes and instrumentation techniques, analysis of electrophysiological data, and coding principles in the nervous system, as well as appropriate background material for the use of microprocessors in neurobiology. Laboratory exercises provide experience in the actual use of microprocessors.]

698 Neuroethology Spring. 4 credits. Prerequisites: Biological Sciences 321 and 496, or their equivalents; or permission of instructor. Offered alternate years.

Lecs, T R 9:05; discs, 2–3 hours each week to be arranged. J. M. Camhi.

The mechanisms through which the natural behavior of animals is produced by the nervous system. Topics include principles of ethology, visual worlds and behavior, auditory worlds and behavior, principles of feature detection, central commands for movement, organization of rhythmic behaviors, feedback control of behavior, and plasticity in the nervous system and behavior. Discussions cover these topics in greater detail. To prepare for the discussions, students are required to read several research papers each week.

720 Seminar in Advanced Topics in Neurobiology and Behavior Fall or spring. Variable credit. May be repeated for credit. Primarily for graduate students; written permission of instructor required for undergraduates. S-U grades optional.

Sem to be arranged. Staff and students.

Designed to provide several study groups each semester on specialized topics. A group may meet for whatever period is judged adequate to enable coverage of the selected topics. Ordinarily, topics are selected and circulated during the preceding semester. Suggestions for topics should be submitted by faculty or students to the chairperson of the Section of Neurobiology and Behavior.

[723 Graduate Seminar in Vertebrate Social Behavior Fall. 2 credits; may be repeated for credit. Enrollment limited. Prerequisites: Biological Sciences 321, 360, and 477, or their equivalents, and written permission of instructor. S-U grades only. Not offered 1981–82.

Sem to be arranged. S. T. Emlen, G. Hausfater.

Intended as a graduate-level follow-up to Biological Sciences 424 and 427. An advanced, participation-format seminar dealing with various aspects of the evolution of social organization in vertebrates.]

Related Courses in Other Departments

Biochemistry and Human Behavior (Psychology 361 and Nutritional Sciences 361)

Mammalian Neurophysiology (Biological Sciences 610)

Teaching Experience (Biological Sciences 498)

Undergraduate Research in Biology (Biological Sciences 499)

Courses in Marine Sciences

Although there is no concentration in marine sciences offered to Cornell undergraduates, there is extensive opportunity to prepare for more advanced study at the graduate level. Students interested in the marine sciences may enroll in courses offered at Cornell's Shoals Marine Laboratory (SML), a seasonal field station located on 95-acre Appledore Island six miles off the Maine and New Hampshire coasts.

The Ithaca campus functions of Shoals Marine Laboratory are centered in the Cornell Marine Programs Office in G14 Stimson Hall. The office serves as an advising center for students interested in the marine sciences; maintains a browsing library with updated information on graduate study and career opportunities, as well as on marine programs at other institutions; and administers the SEA Semester, a 16-credit program offered in cooperation with the Sea Education Association.

The following marine sciences courses are currently administered by the Cornell Marine Programs Office.

312 Anatomy and Behavior of the Gull Summer. 2 credits. Prerequisite: one year of introductory college biology. S-U grades optional. A special 2-week course offered at Cornell's Shoals Marine Laboratory (SML) on an island off Portsmouth, N.H. For more details and application, consult the SML office, Stimson G14. Estimated cost (includes tuition, room and board, and ferry transportation), $565.

Daily lecs, lec-demonstrations, and labs for 2 weeks. SML faculty.

The gull has been a major subject in the study of animal behavior. In this course the functional anatomy of all gull organ systems is considered and demonstrated, with emphasis on sensory, nervous, digestive, and respiratory systems. The large nesting colonies of two species of gulls on Appledore Island are used to demonstrate territoriality, aggression, mating, and other basic patterns of gull behavior.

363 Field Marine Science for Teachers Summer. 1 credit. Primarily for teachers, grades 6 through 12, but open to others. Prerequisite: one year of introductory college biology. S-U grades optional. A special 10-day course offered at Cornell's Shoals Marine Laboratory (SML) on an island off Portsmouth, N.H. For more details and application, consult the SML office, Stimson G14. Estimated cost (includes tuition, room and board, and ferry transportation), $420.

Daily lecs, labs, and fieldwork for 10 days. SML faculty.

Designed to give an overview of living marine organisms (algae, invertebrates, fishes, marine mammals, and shorebirds) and of the environment they inhabit. Fieldwork is emphasized. Occasional lectures and films deal with additional topics, such as coastal zone problems, marine fisheries, economics of marine organisms, and educational resources of the marine environment. The core faculty of marine biologists is augmented by specialists in science and environmental education.

364 Field Marine Science Summer. 6 credits. Prerequisite: one year of college biology or other supporting subject. S-U grades optional. A special 4-week course offered twice each summer at Cornell's Shoals Marine Laboratory (SML) on an island off Portsmouth, N.H. For more details and application, consult the SML office, Stimson G14. Estimated cost (includes tuition, room and board, and ferry transportation), $1,065.

Daily lecs, labs, and fieldwork for 4 weeks. 3 core faculty assisted by up to 15 visiting lecturers, including representatives of government agencies and commercial fishermen. SML faculty.

Designed for the student who desires an initial overview of the marine sciences, this course emphasizes living material in natural habitats. Most of the course work is concerned with the biology of intertidal plants and animals, biological oceanography, ichthyology, and fisheries. Attention also is given to introductory physical and chemical oceanography and marine geology. Marine ecology and the effects of human activity on the marine environment are included.

365 Underwater Research Summer. 2 credits. Prerequisites: recognized scuba certification and a medical examination. S-U grades optional. A special 2-week course offered at Cornell's Shoals Marine Laboratory (SML) on an island off Portsmouth, N.H. For more details and application, consult the SML office, Stimson G14. Estimated cost (includes tuition, room and board, ferry transportation, and compressed air supply), $655.

Daily lecs and fieldwork for 2 weeks. Team-taught by a diving safety officer, a faculty member, and guest lecturers.

For competent divers only. Covers special problems of research underwater, including random sampling, use of dive tables, underwater instrumentation, special diving equipment, photographic techniques, integration with boat and shore facilities, and emergency procedures. Students are required to conduct a transect study on both soft and hard substrates.

366–370 SEA Semester In cooperation with the Sea Education Association (SEA), the Shoals Marine Laboratory offers a semester-length sequence of courses designed to provide college undergraduates with a thorough academic, scientific, and practical understanding of the sea. *This sequence is repeated approximately every 2 months throughout the year.* Students spend the first half of SEA Semester (the 6-week basic shore component) in Woods Hole, Mass., receiving instruction in the marine and nautical sciences and studying our relationship with the sea. The second half of SEA Semester (the 6-week sea component) is spent at sea aboard R/V *Westward*. Applicants are interviewed in Ithaca before admission. Enrollment is open to men and women judged capable of benefiting from SEA Semester; no specific prior training or study is required. *Cornell students enrolled in the SEA Semester must take the entire sequence.*

For more details and applications, consult the Shoals Marine Laboratory office, Stimson G14. Program costs to be paid in place of regular Cornell tuition and fees: tuition for entire 16-credit SEA Semester, about $3,700; room and board for sea component (6 weeks) only, about $400.

Instructors for the SEA Semester include faculty of the SEA, Cornell, Woods Hole Oceanographic Institution, Boston University, and others.

Basic Shore Component (6 weeks)

366 SEA Introduction to Marine Science 3 credits. Prerequisites: a laboratory course in physical or biological science, and concurrent enrollment in Biological Sciences 367 and 368.

A survey of the characteristics and processes of the global ocean. Oceanographic concepts are introduced and developed from their bases in biology, physics, chemistry, and geology. Provides a broad background in oceanography with special attention to areas pertinent to the subsequent *Westward* cruise. Guest lecturers from the Woods Hole research community interpret current trends and activities in this rapidly-evolving field. Students are encouraged to develop individual projects to be carried out at sea.

367 SEA Man and the Sea 2 credits. Prerequisite: concurrent enrollment in Biological Sciences 366 and 368.

An interdisciplinary consideration of our relationship with the marine environment. Included are the political, economic, social, and cultural results of our use of the sea for recreation, scientific research, food, fuel, minerals, and energy-efficient transportation. Covers the elements of maritime history, law, literature, and art necessary to appreciate our marine heritage and to understand contemporary maritime affairs. Examples of mariners' journals are studied in preparation for the diary required of each student at sea.

368 SEA Introduction to Nautical Science 3 credits. Prerequisites: college algebra or equivalent, and concurrent enrollment in Biological Sciences 366 and 367.

An introduction to the technologies of operation at sea. The concepts of navigation (piloting, celestial, and electronic), naval architecture, ship construction, marine engineering systems, and ship management are taught from their bases in physics and astronomy. Provides the theoretical foundation for the navigation, seamanship, and engineering that the student will employ at sea.

Sea Component (6 weeks)

Courses 369 and 370 take place aboard the R/V *Westward*, a 250-ton steel auxiliary-powered staysail schooner built in 1961. *Westward* normally puts to sea with a ship's company of 34. The professional staff of 9 includes the captain, 3 science watch officers, 3 deck watch officers, an engineer, and a steward. In addition, 1 or more visiting investigators are frequently aboard. Up to 25 students round out the complement.

369 SEA Marine Science Laboratory 4 credits. Prerequisite: Biological Sciences 366.

The practice of oceanography at sea. The student is introduced to the oceanic environment, including its biological, physical, chemical, and geological aspects; is instructed in the operation of oceanographic equipment through the taking of samples and measurements; and practices reducing and analyzing data and solving simple problems related to the surrounding oceanic environment. Topics vary with the cruise track but include attention to all of the major subdisciplines of oceanography.

370 SEA Nautical Science Laboratory 4 credits. Prerequisite: Biological Sciences 368.

The practice of nautical science at sea. The student is introduced to the technical and psychological problems of operation and existence in the physical environment of the ocean. Instruction and practice are provided in navigation, seamanship, marine engineering, and shipboard operations. Daily lectures build on the theoretical foundation established by the shore course and deal with the practical problems and applications presented by ship operation. During the final two weeks at sea, each student is expected to demonstrate, in succession, competence as navigator, deck watch officer and engineering watch officer.

413 Adaptations of Marine Organisms Summer. 4 credits. Prerequisite: Biological Sciences 364 or 315 or a course in physiological ecology. S-U grades optional. A special 3-week course offered at Cornell's Shoals Marine Laboratory (SML) on an island off Portsmouth, N.H. For more details and application, consult the SML office, Stimson G14. Estimated cost (includes tuition, room and board, and ferry transportation), $825.

Daily lecs, labs, and fieldwork for 3 weeks. SML faculty.

An introduction to the physiological ecology and functional morphology of marine plants and animals with emphasis on selected algal and invertebrate examples from the Gulf of Maine. Topics covered include photosynthesis in the marine environment; respiration in intertidal organisms; carbohydrates, proteins, and lipids as nutrients in the sea; acclimation and tolerance of tide pool biota; and biological responses to competition and grazing. Field and laboratory exercises explore principles and procedures used to characterize the physical, chemical, and biotic environment of intertidal and shallow subtidal organisms including determination of temperature, light, salinity, oxygen and nutrient levels, and *in vivo* functional analyses of metabolic phenomena.

441 (346) Field Phycology Summer. 4 credits. Prerequisite: Biological Sciences 364 or general familiarity with marine algae. S-U grades optional. A special 3-week course offered at Cornell's Shoals Marine Laboratory (SML) on an island off Portsmouth, N.H. For more details and application, consult the SML office, Stimson G14. Estimated cost (includes tuition, room and board, and ferry transportation), $825.

Daily lecs, labs, and fieldwork for 3 weeks. SML faculty.

An overview of the major marine algal groups, including aspects of anatomy, morphology, development, life histories, physiology, and utilization. Laboratories and fieldwork emphasize relationships between distribution and major environmental parameters and involve student projects.

467 (362) Chemical Oceanography in the Field Summer. 4 credits. Prerequisites: one year of introductory college chemistry and an introductory marine science course at the college level. S-U grades optional. A special 3-week course offered at Cornell's Shoals Marine Laboratory (SML) on an island off Portsmouth, N.H. For more details and application, consult the SML office, Stimson G14. Estimated cost (includes tuition, room and board, and ferry transportation), $825.

Daily lecs, labs, and fieldwork for 3 weeks. SML faculty.

A field-oriented course in the chemical oceanography of coastal waters. Lectures, frequent field trips, and laboratory sampling and analysis; includes tests of salinity, temperature, pH, chlorophyll, alkalinity, total CO_2, nutrients, organic material, and suspended materials in coastal waters, with some work on the analysis of coastal sediments.

473 Topics in Marine Vertebrates Summer. 4 credits. Prerequisite: Biological Sciences 364 or 274 or a course in vertebrate biology. S-U grades optional. A special 3-week course offered at Cornell's Shoals Marine Laboratory (SML) on an island off Portsmouth, N.H. For more details and application, consult the SML office, Stimson G14. Estimated cost (includes tuition, room and board, and ferry transportation), $825.

Daily lecs, labs, and fieldwork for 3 weeks. SML faculty.

Topics in marine vertebrate biology emphasizing laboratory studies, field collections or observations, and readings from the current literature. Topics covered include: systematics of fishes of the Gulf of Maine; elasmobranch physiology; interpretation of life history and parameters from otolith microstructure; teleost skeletomuscular structure and function; population biology and the contemporary Gulf of Maine fishery; Mesozoic marine reptiles; the biology of sea turtles in cold water; coloniality in sea birds; avian adaptations to life at sea; evolution and systematics of marine mammals; diving physiology; and ecology and conservation of existing marine mammal populations.

482 (384) Invertebrate Embryology Summer. 4 credits. Prerequisite: Biological Sciences 364 or a course in invertebrate zoology. S-U grades optional. A special 3-week course offered at Cornell's Shoals Marine Laboratory (SML) on an island off Portsmouth, N.H. For more details and application, consult the SML office, Stimson G14. Estimated cost (includes tuition, room and board, and ferry transportation), $825.

Daily lecs, labs, and fieldwork for 3 weeks. SML faculty.

A laboratory-oriented course emphasizing processes of fertilization and early development through the metamorphosis of larvae in species selected from an extensive variety of local marine invertebrates. Practical experience includes collecting specimens intertidally and from the plankton, culturing embryos through metamorphosis, camera lucida and photomicrographic recording of embryonic development, and design and execution of basic experiments on eggs and embryos. Lectures complement laboratory work through phylogenetic examination of classical invertebrate embryology and modern experimental developmental biology.

Coastal and Oceanic Law and Policy (Natural Resources 306) Summer. 1 credit. A special 1-week course offered at Cornell's Shoals Marine Laboratory (SML) on an island off Portsmouth, N.H. For more details and application, consult the SML office, Stimson G14. Estimated cost (includes tuition, room and board, and ferry transportation), $290.

Daily lecs and discs for 1 week. SML faculty.

Intended for persons interested in careers in management of marine or coastal resources or in the natural sciences. Subjects include law and policy related to ocean dumping, marine sanctuaries, environmental impact statements, water and air pollution, fisheries management, offshore gas and oil production, and territorial jurisdiction. Lectures on the status and history of the law are accompanied by discussion of relevant policy and analysis of the efficacy of various legal techniques. A case study that requires extensive use of the laboratory's library and personnel is assigned. The week concludes with a mock hearing.

Wetland Resources (Natural Resources 417) Summer. 1 credit. Prerequisite: one year of college biology. A special 1-week course offered at Cornell's Shoals Marine Laboratory (SML) on an island off Portsmouth, N.H. For more details and application, consult the SML office, Stimson G14. Estimated cost (includes tuition, room and board, and ferry transportation), $310.

Daily lecs, labs, and fieldwork for 1 week. SML faculty.

An examination of coastal and adjacent freshwater wetlands from historic, destruction, and preservation perspectives, including fresh and salt marsh ecology and management. Field trips to selected examples of the wetlands under discussion and follow-up laboratories emphasize successional features, plant identification and classification, and examination of the dominant insect and vertebrate associations.

Introduction to Marine Pollution and Its Control Summer. 2 credits. Prerequisite: Biological Sciences 364 or permission of instructor. A special 2-week course offered at Cornell's Shoals Marine Laboratory (SML) on an island off Portsmouth, N.H. For more details and application, consult the SML office, Stimson G14. Estimated cost (includes tuition, room and board, and ferry transportation), $565.

Daily lecs, labs, and fieldwork for 2 weeks. SML faculty.

Dispersion modeling and the effects of pollutants (including oil, outfalls, solid wastes, sludge and dredge spoils, and radioactive wastes) are discussed from the perspectives of elementary physical oceanography and biological processes. Laboratories include basic methods for targeting and tracing waste water; organic carbon determinations; microbial tests for *Salmonella, E. coli,* and *Streptococcus;* and practical field projects.

Courses in Biophysics

Biophysics is an interdisciplinary undergraduate and graduate program. A special program for undergraduate students interested in biophysics is offered as an independent concentration in the biological sciences major (see option 8 under Concentration Areas and Requirements). Information on this independent option is available in the Office for Academic Affairs, 118 Stimson Hall. Students interested in graduate work in biophysics should inquire at the Program in Biophysics office, 210 Clark Hall.

The following courses are available for students interested in biophysics:

Animal Communication (Biological Sciences 423)

Bioenergetics and Membranes (Biological Sciences 632)

Biomechanical Systems—Analysis and Design (Engineering M&AE 565)

Chemistry of Nucleic Acids (Chemistry 677)

Electron Microscopy for Biologists (Biological Sciences 600, 602, 603, 604, 606, 608)

Enzyme Catalysis and Regulation (Chemistry 672)

Membrane Biophysics (Engineering A&EP 615)

Modern Physical Methods in Macromolecular Structure Determination (Engineering A&EP 616)

Neuroelectric Systems (Biological Sciences 696 and Electrical Engineering 622)

Photosynthesis (Biological Sciences 445 and Engineering A&EP 601)

Physical Chemistry of Proteins (Chemistry 686)

Physics of Macromolecules (Physics 464)

Principles of Neurobiology, Laboratory (Biological Sciences and Psychology 491)

Protein Structure and Function (Biological Sciences 631)

Special Topics in Biophysical and Bioorganic Chemistry (Chemistry 782)

Special Topics in Biophysics (Engineering A&EP 614)

The Physics of Life (Engineering A&EP 206)

Transport of Solutes and Water in Plants (Biological Sciences 649)

Vision (Biological Sciences 395 and Engineering A&EP 611)

Faculty Roster

New York State College of Agriculture and Life Sciences

Adler, Kraig K., Ph.D., U. of Michigan. Prof., Neurobiology and Behavior

Barker, Robert, Ph.D., U. of California at Berkeley. Prof., Biochemistry, Molecular and Cell Biology*

Barlow, John P., Ph.D., Harvard U. Assoc. Prof., Ecology and Systematics

Bates, David M., Ph.D., U. of California at Los Angeles. Prof., Bailey Hortorium

Beyenbach, Klaus W., Ph.D., Washington State U. Asst. Prof., Physiology/Veterinary Physiology†

Brothers, Edward B., Ph.D., U. of California at San Diego. Asst. Prof., Ecology and Systematics

Bruns, Peter J., Ph.D., U. of Illinois. Assoc. Prof., Genetics and Development*

Brussard, Peter F., Ph.D., Stanford U. Assoc. Prof., Ecology and Systematics*

Cade, Thomas J., Ph.D., U. of California at Los Angeles. Prof., Ecology and Systematics

Calvo, Joseph M., Ph.D., Washington State U. Prof., Biochemistry, Molecular and Cell Biology

Camhi, Jeffrey M., Ph.D., Harvard U. Prof., Neurobiology and Behavior

Clayton, Roderick K., Ph.D., California Inst. of Technology. Prof., Plant Biology/Applied and Engineering Physics¶

Davies, Peter J., Ph.D., U. of Reading. Assoc. Prof., Plant Biology

Dress, William J., Ph.D., Cornell U. Prof., Bailey Hortorium

Edelstein, Stuart J., Ph.D., U. of California at Berkeley. Prof., Biochemistry, Molecular and Cell Biology*

Eisner, Thomas, Ph.D., Harvard U. Jacob Gould Schurman Professor, Neurobiology and Behavior

Feeny, Paul P., Ph.D., Oxford U. Prof., Ecology and Systematics/Entomology

Fink, Gerald R., Ph.D., Yale U. Prof., Biochemistry, Molecular and Cell Biology/Genetics and Development

Fox, Thomas D., Ph.D., Harvard U. Asst. Prof., Genetics and Development

Gibson, Jane, Ph.D., U. of London. Prof., Biochemistry, Molecular and Cell Biology

Harris-Warrick, Ronald M., Ph.D., Stanford U. Asst. Prof., Neurobiology and Behavior

Hausfater, Glenn, Ph.D., U. of Chicago. Assoc. Prof., Neurobiology and Behavior

Ingram, John W., Jr., Ph.D., U. of California at Berkeley. Assoc. Prof., Bailey Hortorium

Jagendorf, Andre T., Ph.D., Yale U. Prof., Plant Biology

Keller, Elizabeth B., Ph.D., Cornell U. Assoc. Prof., Biochemistry, Molecular and Cell Biology

Kingsbury, John M., Ph.D., Harvard U. Prof., Plant Biology/Clinical Sciences†

Lis, John T., Ph.D., Brandeis U. Asst. Prof., Biochemistry, Molecular and Cell Biology

Loew, Ellis R., Ph.D., U. of California at Los Angeles. Asst. Prof., Physiology/Veterinary Physiology†

MacDonald, Russell E., Ph.D., U. of Michigan. Prof., Biochemistry, Molecular and Cell Biology

MacIntyre, Ross J., Ph.D., Johns Hopkins U. Prof., Genetics and Development

Marks, Peter L., Ph.D., Yale U. Assoc. Prof., Ecology and Systematics*

Moffat, J. Keith, Ph.D., Cambridge U. Assoc. Prof., Biochemistry, Molecular and Cell Biology

Niklas, Karl J., Ph.D., U. of Illinois. Asst. Prof., Plant Biology
Paolillo, Dominick J., Jr., Ph.D., U. of California at Davis. Prof., Plant Biology
Parthasarathy, Mandayam V., Ph.D., Cornell U. Assoc. Prof., Plant Biology*
Pough, F. Harvey, Ph.D., U. of California at Los Angeles. Assoc. Prof., Ecology and Systematics/Physiology
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Root, Richard B., Ph.D., U. of California at Berkeley. Prof., Ecology and Systematics/Entomology
Spanswick, Roger M., Ph.D., U. of Edinburgh. Prof., Plant Biology
Srb, Adrian M., Ph.D., Stanford U. Jacob Gould Schurman Professor, Genetics and Development*
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Uhl, Natalie W., Ph.D., Cornell U. Assoc. Prof., Bailey Hortorium
Vogt, Volker M., Ph.D., Harvard U. Asst. Prof., Biochemistry, Molecular and Cell Biology
Whalen, Michael D., Ph.D., U. of Texas at Austin. Asst. Prof., Bailey Hortorium/Ecology and Systematics
Zahler, Stanley A., Ph.D., U. of Chicago. Prof., Genetics and Development*

Joint Appointees

Alexander, Martin, Liberty Hyde Bailey Professor of Soil Science, Agronomy/Ecology and Systematics
Bloom, Stephen E., Assoc. Prof., Poultry and Avian Sciences/Biological Sciences
Borror, Arthur C., Adjunct Prof., U. of New Hampshire/Biological Sciences
Brown, William L., Jr., Prof., Entomology/Ecology and Systematics
Butler, Walter R., Assoc. Prof., Animal Science/Physiology
Currie, W. Bruce, Asst. Prof., Animal Science/Physiology
Delwiche, Eugene A., Prof., Microbiology/Biological Sciences
Foote, Robert H., Jacob Gould Schurman Professor, Animal Science/Physiology
LaRue, Thomas A., Adjunct Prof., Boyce Thompson Institute/Plant Biology
Leopold, A. Carl, Adjunct Prof., Boyce Thompson Institute/Plant Biology
Madison, James T., Adjunct Asst. Prof., USDA Science and Education Administration/Biological Sciences
Novak, Joseph D., Prof., Education/Biological Sciences
Pimentel, David, Prof., Entomology/Ecology and Systematics
Richmond, Milo E., Assoc. Prof., USDI Fish and Wildlife Service/Natural Resources/Ecology and Systematics
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Thompson, John F., Adjunct Prof., USDA Science and Education Administration/Plant Biology
VanDemark, Paul J., Prof., Microbiology/Biological Sciences
van Tienhoven, Ari, Prof., Poultry and Avian Sciences/Physiology

College of Arts and Sciences

Blackler, Antonie W., Ph.D., U. of London (England). Prof., Genetics and Development
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Campenot, Robert B., Ph.D., Massachusetts Inst. of Technology. Asst. Prof., Neurobiology and Behavior
Capranica, Robert R., Sc.D., Massachusetts Inst. of Technology. Prof., Neurobiology and Behavior/Electrical Engineering¶
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Emlen, Stephen T., Ph.D., U. of Michigan. Prof., Neurobiology and Behavior‡
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Fessenden-Raden, June M., Ph.D., Tufts U. Assoc. Prof., Biochemistry, Molecular and Cell Biology
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McCarty, Richard E., Ph.D., Johns Hopkins U. Prof., Biochemistry, Molecular and Cell Biology‡
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Wu, Ray, Ph.D., U. of Pennsylvania. Prof., Biochemistry, Molecular and Cell Biology

Joint Appointees

Hammes, Gordon G., Horace White Professor of Chemistry and Biochemistry, Chemistry/Biochemistry, Molecular and Cell Biology
Provine, William B., Assoc. Prof., History/Biological Sciences
Regan, Elizabeth Adkins, Asst. Prof., Psychology/Neurobiology and Behavior
Rhee, G-Yull, Adjunct Assoc. Prof., NYS Department of Health/Ecology and Systematics
Risch, Stephen J., Asst. Prof., STS/Ecology and Systematics

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Tapper, Daniel N., Ph.D., Cornell U. Prof., Physiology/Neurobiology and Behavior/Veterinary Physiology
Wasserman, Robert H., Ph.D., Cornell U. Prof., Physiology/Veterinary Physiology/Nutritional Sciences

Joint Appointees

Bergman, Emmett N., Prof., Veterinary Physiology/Physiology
Dobson, Alan, Prof., Veterinary Physiology/Physiology
Evans, Howard E., Prof., Anatomy/Biological Sciences
Gillespie, James H., Prof., Microbiology/Biological Sciences
Houpt, Katherine A., Asst. Prof., Veterinary Physiology/Physiology
Houpt, T. Richard, Prof., Veterinary Physiology/Physiology

College of Engineering

Joint Appointee

Cisne, John L., Asst. Prof., Geological Sciences/Biological Sciences

Division of Nutritional Sciences

Joint Appointees

Arion, William J., Prof., Nutritional Sciences/Biochemistry, Molecular and Cell Biology
Bensadoun, Andre, Prof., Nutritional Sciences/Physiology
Dills, William L., Jr., Asst. Prof., Nutritional Sciences/Biochemistry, Molecular and Cell Biology
Kazarinoff, Michael N., Asst. Prof., Nutritional Sciences/Biochemistry, Molecular and Cell Biology
Zilversmit, Donald B., Prof., Nutritional Sciences/Biochemistry, Molecular and Cell Biology

*Joint appointment with the College of Arts and Sciences.
†Joint appointment with the College of Veterinary Medicine.
‡Joint appointment with the College of Agriculture and Life Sciences.
¶Joint appointment with the College of Engineering.